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The ADVANCEMENT OF SCIENCE

The Report of the

British Association

for the Advancement of Science

SCIENCE AND WORLD ORDER

Transactions of a Conference of the Division for the Social and International Relations of Science

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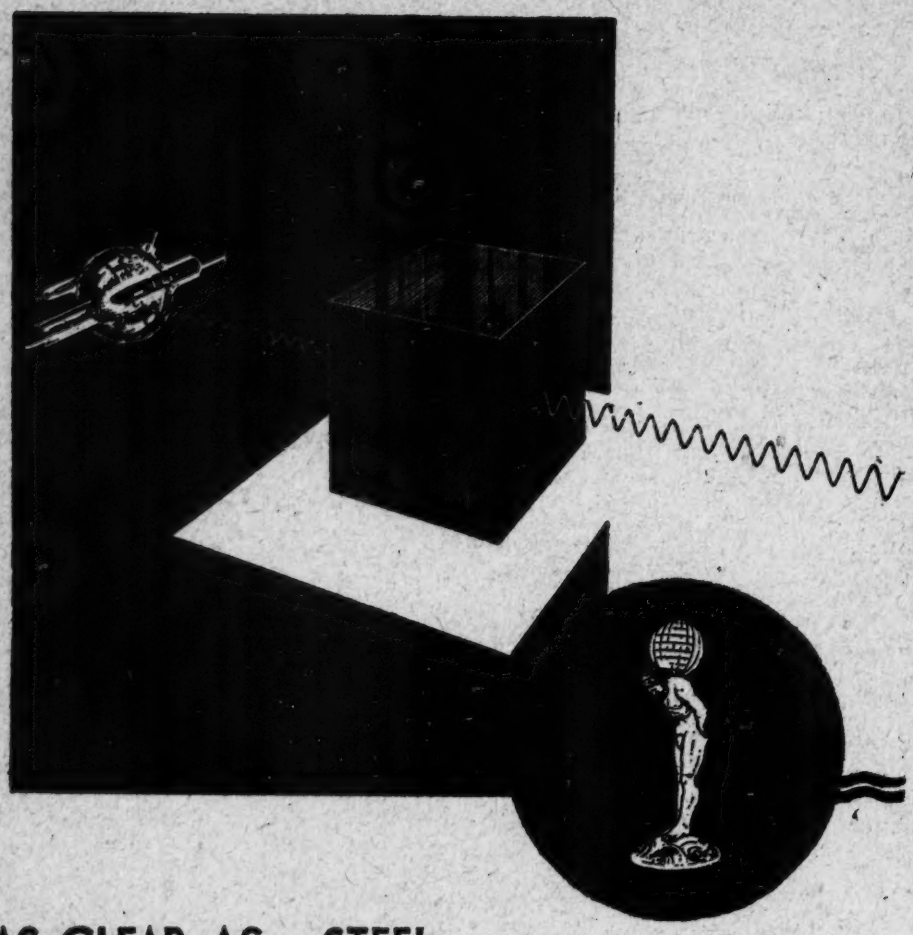

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THE ADVANCEMENT OF SCIENCE

VOL. II, No. 5

SCIENCE AND WORLD ORDER

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INTRODUCTION

In the preceding issue of this journal, which appeared in July 1940, it was announced that, subject to unforeseen circumstances, a conference would be held at the end of that month by the Division for the Social and International Relations of Science, in the University of Reading. The general subject for that conference was to have been ' Science in National and International Aspects ' ; but war conditions at the time caused the conference to be abandoned when arrangements were far advanced. Later, it became possible again to consider the holding of a conference, and the Divisional Committee, at a meeting held on July 17, 1941, decided that this should be done in September, under the general title of Science and World Order. It is the transactions of this conference which form the contents of the present issue of *The Advancement of Science*. The changes in the format of this issue as compared with previous numbers have been dictated by the need for a reduced use of paper.

The Divisional Committee appointed a Programme Subcommittee for the Conference, consisting of the General Officers, Mr. Ritchie Calder, Prof. S. Chapman, F.R.S., Dr. C. H. Desch, F.R.S., and Dr. J. S. Huxley, F.R.S. Mr. J. G. Crowther, Prof. A. V. Hill, M.P., Sec. R.S., and Mr. D. P. Riley were subsequently co-opted into this subcommittee, which had also the help of a number of assessors in connection with special points of the programme. The days of the Conference were fixed as Friday, Saturday, and Sunday, September 26, 27, 28, and it was at first intended to hold the opening day's sessions in London, and those on the two following days at Rothamsted Experimental Station, Harpenden. But as the programme took shape, it became evident that the general interest in it was so great as to make it desirable to hold all the sessions in London, and the Royal Institution most generously allowed this to be done in its building in Albemarle Street, where, it must be gratefully added, the staff of the Institution rendered services without which the smooth working of the Conference would have been impossible. Foreign governments and other foreign institutions in London were apprised of the Conference, and the collaboration of representatives of many of these was greatly appreciated. A number of students of the Imperial College of Science and Technology gave valuable help as stewards. It has only to be regretted that so large was the demand for tickets for the Conference that a considerable number of applicants could not be accommodated. The press and the B.B.C. gave the Conference a very wide publicity, both at home and abroad. Messrs. Paul Rotha Productions, Ltd., in collaboration with the Ministry of Information, made speaking films of a number of the speakers at the Conference.

On Thursday, September 25, the British Council gave a luncheon at the Savoy Hotel to British and foreign representatives of science assembled for the Conference. The Rt. Hon. Sir Malcolm Robertson, G.C.M.G., K.B.E., M.P., chairman of the Council, was in the chair, and the Rt. Hon. Anthony Eden, P.C., M.P., Secretary of State for Foreign Affairs, gave an address. He said that the Government had to call upon men of science to help in the cause for which they were now fighting, and would need them even more for the cause for which they would be working in peace. He showed how Germany was intellectually encircled, having renounced the international spirit of science, and having made German scientists the slaves of a régime which was opposed to everything science represented. If after the war we were to have any chance to battle against inequalities, selfishness, unfair division, and materialism, science and statecraft must work together, and it was for statecraft to see that the fruits of scientists' planning were not misused. The speaker referred to the Conference of Allied Nations which had recently taken place at St. James's Palace, and said that both at this and at the scientific conference about to be held, men were trying to lay the foundations of a better world.

At a meeting of the Divisional Committee held on October 14, 1941, it was resolved that : ' On behalf of the Officers and executive of the British Association for the Advancement of Science, and of all those members of the Association and others who took part in the recent Conference on Science and World Order, the Divisional Committee for the Social and International Relations of Science tenders warmest thanks to the institutions and individuals who so generously collaborated with the committee in the arrangements for the meeting, and thereby assured its success.' The thanks of the Committee were specially extended to the Programme Subcommittee.

SCIENCE AND GOVERNMENT

FRIDAY, SEPTEMBER 26 : MORNING SESSION

CHAIRMAN : SIR RICHARD GREGORY, BT., F.R.S., PRESIDENT OF THE ASSOCIATION

The Chairman

THE Chairman communicated to the Conference the following message which he was about to transmit to His Majesty the King :

The President of the British Association, with humble duty, begs leave to bring to the notice of His Majesty the King the conference of the Association's Division for the Social and International Relations of Science, which opens to-day for the discussion of the place which Science should find in World order, its relations with the democratic State, its contributions to the relief of human needs and suffering, its potentialities in connection with the just distribution of world resources, and the influence which by its example it should bring to bear in directing the minds of men toward peaceful collaboration in future for the common welfare.

In conference with members of the British Association and other representatives of science, administration, and education in this country, there are present many who have come to us from Your Majesty's Dominions and other lands, and assuredly such an occasion as this will help to strengthen the bond between the free peoples.

That such a conference should be held here at such a time, we take to be a fortunate symbol of that freedom in the pursuit of knowledge which we ourselves treasure and are striving to restore to all those who now are deprived of it.

His Majesty's reply, communicated to the Conference at a subsequent session, was as follows :

The President of the British Association for the Advancement of Science.

I thank you sincerely for your message on the occasion of the opening of the conference held by the Division of the British Association for Social and International Relations of Science which was so wisely established a few years ago. The social benefits which scientific research, by free practice and under right guidance, can bestow on all mankind, grow ever greater. It is right that such benefits should be shared among all peoples alike.

I am happy, therefore, to join with you in welcoming the many distinguished scientists from overseas and in thanking them for the free gift of their knowledge.

I sincerely hope that this valuable interchange of ideas will further the lofty aims which the British Association has consistently pursued since its foundation.

GEORGE R.I.

The Chairman, in opening the proceedings, also read the following message from the Prime Minister, the Rt. Hon. Winston Churchill :

I regret that I am not able to be present at the opening of your conference.

One of our objects in fighting this war is to maintain the right of free discussion and the interchange of ideas. In contrast to the intellectual darkness which is descending on Germany, the freedom that our scientists enjoy is a valuable weapon to us, for superiority in scientific development is a vital factor in the preparation of victory. The presence of the representatives of so many different nations is striking proof of that universal desire for liberty of thought which all the power of the Gestapo will never entirely stamp out. It will take a long time for the civilised powers to repair the trail of material and moral havoc which Germans leave behind them. It will require all the resources of science. But I look forward to the day when the scientists of every nation can devote all their energies to the common task, and I wish you every success in the work you are undertaking now.

W. S. C.

24*th September* 1941.

The Chairman continued :

It may be appropriate for me to say a few words about the object of this Conference. The Division for the Social and International Relations of Science of the British Association was established at the Cambridge meeting of the Association three years ago. Its purposes are to further the objective study of the effects of advances in science upon social conditions and to promote the welfare of human communities by international understanding of them.

When it was decided to hold this Conference, or rather to hold a meeting of the Division, it was not anticipated that the welcome to it would be so great or so widespread as it has proved to be. The original idea was to have a few papers in order that we might consider almost amongst ourselves, as members of the Division, some of those contacts of science which affect civilised life to-day in

peace and war to such a very great extent. But the presence of a number of representative men of science in this country from nationalities other than our own and outside the British Commonwealth, made it desirable that they too should be given an opportunity upon such an occasion as this of expressing their views and presenting the results of their inquiries.

This has had the result that our programme has become almost over-full. It is necessary therefore to reduce the time-periods that were originally to be devoted to certain papers. These have had to be reduced in length and every speaker has been asked to limit himself to a short statement, to enable the Conference to be an occasion when as many representatives as possible of the free peoples of the great democracies may be given an opportunity of expressing themselves in sympathy with the spirit of this Division of the British Association.

The Conference may almost be regarded as an international gesture for the consideration of world problems, not from the point of view of any one nation but of the whole world. Science is a commonwealth in itself—a community in which there are no social, racial, or geographical distinctions. Its principles are truly democratic. What may be termed the scientific principles of all free peoples are 'liberty to learn, freedom to express, opportunity to develop.' Those are among the basic principles of science and they are the principles claimed by free citizens of all countries. We stand, therefore, as representatives of science to maintain those principles, particularly to-day against the cruel and barbarous assaults that are being made upon them. We stand as representatives of science for those very principles of order and fellowship within the human race by which alone we can hope to preserve what is best in civilisation and to feel confidence in a higher destiny for humanity. Unless we do maintain those fundamental rights—rights which belong to all humanity—and take an effective part in the control of the evil influences which would destroy those ideals, the world will be reduced to a place of dust and ashes.

At the end of our closing session we shall put forward a Declaration of Scientific Principles, which are the basic principles also of a true democracy, and affirm them as principles which we are prepared to maintain against all attacks. In the spirit of those principles we will do all within our power as free men to unite with other citizens for the salvation of the world.

We have received many messages from abroad. One of these is from our corresponding association in America—the American Association for Advancement of Science. Another is from the Society of German Scholars in Exile, and others come from the Free German League of Culture in Great Britain, the Council of Austria in Great Britain, and a number of other communities representing not only men of science but citizens generally, welcoming this Conference and putting forward suggestions for giving collective shape to what emerges from it. It is a most encouraging thing in these days that a Conference which is not concerned with the dominion of any one people in the world but desires to consider everything from the point of view of all humanity should receive so great a welcome on all sides.

Rt. Hon. Viscount Samuel, P.C., G.C.B., G.B.E. THE scientific spirit has developed slowly in Great Britain, especially in the sphere of government. No doubt that is due to the system of the education of the classes from which our ministers, members of both Houses of Parliament, and civil servants have been mainly drawn—its concentration on classics and literature. For example, none of our Prime Ministers has been at all science-minded, except Lord Salisbury, Mr. Balfour, and Mr. Ramsay MacDonald. Fortunately, during and after the last war, the nation bestirred itself. The establishment of the Department of Scientific and Industrial Research in 1916 was a landmark. The advance made came just in time. It is science which in this country has given us technical superiority in the air ; has enabled us quickly to master such dangers as the magnetic mine, which otherwise might have been fatal ; has placed us on an equality, if not in the quantity, certainly in the efficiency of the implements of war and the ancillary services. If, as was said, the Battle of Waterloo was won on the playing-fields of Eton, we may say now that the Battle of Britain and the Battle of the Atlantic are being won in our physical and chemical laboratories.

If a Conference such as this had been summoned a year ago, our foreign colleagues would have found us in a very critical mood. At that time our resources in scientific knowledge and ability were still very insufficiently used. Many of the younger men, capable and energetic, had been left aside ; but of late there has been a marked advance. Last April, I raised this question in the House of Lords, and Lord Hankey, in reply, speaking as Chairman of the Scientific Advisory Committee of the War Cabinet, announced the intentions of the Government and described the organisation which is now in operation.

At the centre there is the Hankey Committee, consisting of a small number of our ablest and most distinguished men of science—co-ordinating, initiating, stimulating. It keeps in closest touch with the three great permanent organisations for research on the civil side. First, the Department of Scientific and Industrial Research, with its ten Institutes and thirty-three Advisory Boards or Committees. Secondly, the Medical Research

Council, which also has a ramification of specialised institutions of various kinds : it deals not only with medical matters in the ordinary sense, but with all problems of human health and efficiency. Thirdly, the Agricultural Research Council. On the military side the Advisory Committee co-operates with the important organisations in the four Departments concerned—the Admiralty, and the Ministries of Supply, Aircraft Production, and Home Security. All of these have various research establishments of their own—more than a score altogether. There is, further, an elaborate system for the examination of new inventions. The various sections of all this vast organisation keep in touch with corresponding bodies in the Dominions, India, the Colonies, and, perhaps more important still, the United States. Close attention is given to the enlistment of specialists from other countries who now find themselves in this country as the result of religious, racial or political persecution. A number of them are at work in the research laboratories, mostly, so far as Government employment is concerned, on the medical side, but also in industry.

I would repeat here a suggestion which I made in that discussion in the House of Lords, originally put forward some years ago by the late Professor Graham Wallas. In order to gain advantage quickly from the developments in science in the various countries of the world, and in order to promote international co-operation, it is suggested that our Government should appoint science attachés to our principal embassies. We have now military, naval and air attachés, and commercial and press attachés as well. There is much to be said for the appointment of qualified scientific men, whose duty it would be to keep a constant watch on the inventions, processes and systems of organisation elsewhere that are likely to be of value to our own country, in order to bring them to the attention of the responsible authorities.

From this description of the widespread system that is now functioning, it will be clear that science in this country is no longer undervalued by the Government. How far the system works with efficiency ; whether there is an ever-present sense of extreme urgency such as our critical times demand ; how far the system is adequate for its purpose, other speakers at this Conference will be in a position to say. No one in the Government or out of it would contend that all is being done that should be done, that no fresh stimulus is ever called for, and that every criticism must be foolish.

Our prime effort must be for the successful conduct of the war. Everything must take second place to that. But in that second place, not to be neglected, is the shaping of the international system that is to follow the war, the outline of which has been given in the great Atlantic Charter. Side by side with that is the movement for the bettering of our own country ; for ridding our social system of the grave defects, the many injustices that degrade it ; for moulding the physical environment of the people so as to conduce to the development of the best types of human being. Man is not compelled, like the animals, to be the passive product of whatever environment there may chance to be. With us evolution may become conscious. We should aim at changing the inherited environment, so that the present generation, and those that follow, may reach nobler standards. Hence the movement, now more active than ever before, to promote on proper lines the physical planning of town and country. It is evident that when the war stops, social problems of great urgency and on a vast scale will arise, and that it is essential that preparations should be made well in advance. Millions of people demobilised from the Forces and released from munitions will present a grave problem of employment. At the same time, devastated towns will be eager to rebuild, and scattered families will be impatient to reunite in new homes. There will be three years or more of normal building in arrear. It is of the first importance that the necessary legislation should be placed beforehand on the Statute Book, that local schemes should be perfected, and the negotiations completed. Here is one more province which modern science must enter. A new social science has arisen, of town and country planning. We need, also, much more scientific activity than has hitherto been forthcoming in one special department of the same sphere—the planning of the buildings themselves and the materials of construction. Already there is a Building Research Station, and many architects with foresight are giving their minds to these subjects. Some of them have formed an Architectural Science Board, with a view to finding out what further researches are now needed, and how to influence the profession and the public to secure that those researches shall be undertaken and their lessons learnt. I would commend these new branches of scientific activity to your special attention.

The assembly of this Conference at such a time is a sign that scientists feel themselves to be not merely technicians, nor yet abstract theorists, but citizens, bearing special responsibilities on account of special qualifications to take part in the ordering of human affairs. When we observe the unhappy plight of our times and reflect upon the causes, the lesson we are bound to draw is surely this—that Science has the duty to share, actively and keenly, in the search for the remedies. She is not alone. Religion and Philosophy are engaged in the same quest. These three activities of the human mind cannot be antagonistic to one another : they cannot even be separate and apart. Only when they recognise, all three of them—science, religion and philosophy—that they are interdependent, only when they move together in search of the common goal, will the problems of our troubled age approach their solution.

Prof. A. V. Hill, M.P., Sec. R.S.

The Use and Misuse of Science in Government [1]

WARMLY, therefore, as one may welcome a conference of this kind, anxious as one may be to see all the resources of science, its results, its methods, and its habits of mind used in the service of the State, it is necessary to urge—and to go on urging—that unless the independence and objectivity of science are upheld more harm than good may result. It is so easy, for sentimental reasons, to

[1] The first part of this paper, dealing with the danger of allowing scientific conclusions to be influenced by political considerations or emotion, has been omitted. The paper is printed in full in *The Engineer* of 4 Oct. 1941.

tumble into sloppy thinking. It is so easy to follow the fashion and find in science a universal cure-all. It is so easy to acquire cheap fame by using specious scientific arguments to bolster up some popular or partisan belief. Not only, thereby, is damage done to the State, but the high repute of science itself, built up slowly over generations by the integrity of its followers, is lowered.

Not only, however, by allowing one's thinking apparatus to be tied to one's interests or emotions, but in other ways may science in government be misused. The primary difficulty is that the bureaucratic method, with its authority, its routine, its discouragement of initiative, its lack of freedom and criticism, its secrecy, provides the antithesis of the environment in which good scientific work is usually done.

I know well enough that planning and direction are necessary in government and industrial research ; but somehow the spirit of freedom and initiative, of criticism, of intellectual equality between senior and junior, must be combined with them if science is not to be frustrated. This is not impossible. There are Government establishments in which the spirit is 100 per cent. right ; unfortunately, there are others in which it is miserably wrong. The spirit is likely to be better where contact with outside science is the rule, where publication is normally permitted, where criticism and discussion are possible, where something more like the atmosphere of a university exists, and where a guiding and inspiring influence can be exercised, sometimes behind the scenes, by advisory bodies of experienced independent scientists. Such conditions exist in ordinary times to a greater degree than elsewhere in the laboratories and establishments of the three Research Councils, and of the Research Associations which are partly under Government and partly under Industry. The Civil Defence Research Committee, working for the Ministry of Home Security, provides an excellent example in wartime. Let us specially consider, since they are vitally concerned with the utilisation of science, the Service and Supply Departments.

In the research establishments of the Ministry of Supply the Scientific Advisory Council and its numerous committees, chiefly composed of independent scientists (including engineers), exert a considerable and beneficial influence. By personal visits and contacts, by holding meetings at the stations themselves, and in a variety of ways, members of the committees can help to keep the workers in these establishments in contact with outside ideas and criticism, and to see that unnecessary routine and formality do not hinder their efforts or thwart their initiative. Had this organisation existed before 1940, we should have been more ready for a scientific war. Fortunately, the Chemical Defence Board and a few similar bodies had continued to get the assistance of independent scientists ever since 1918. One may hope that neither false economy nor pacifism will bring such co-operation to a premature end once more.

The Admiralty, on the other hand, with its traditional devotion to secrecy, has always resisted any suggestion that an advisory council, containing independent scientists, should be set up to take an interest in its research. Much first-class work, of course, has been, and is being, done in Admiralty establishments, and the nation is deeply in their debt ; even that, however, would have been helped and quickened by an advisory organisation similar to that of the Ministry of Supply ; and for the rest, one suspects that secrecy—often admittedly essential—is sometimes extended (perhaps unconsciously, for people are seldom aware of their real motives) to hold criticism at arm's length. Fortunately, a beginning has at last been made by the appointment this year of a small advisory panel containing two independent scientists—compared with about fifty helping the Ministry of Supply !

In the Air Ministry, and now in the Ministry of Aircraft Production, the conditions are intermediate. Radiolocation, the most important scientific development of the war, started with an independent scientific committee working with the Director of Scientific Research as far back as 1935. Scientific bodies of various kinds now advise the two Ministries, and, fortunately, Sir Henry Tizard is at last in a position to give his unique knowledge and experience unhindered to the scientific needs of air warfare. Much first-class work is done in the scientific establishments of the M.A.P., and secrecy is not such an obsession as with the Admiralty. It would be wiser, however, to stabilise the use of external scientific advice by some constitutional organisation analogous to that of the Ministry of Supply.

One general reflection of great importance may be made on science in connection with the Services. It refers to the necessity of having scientific men of high quality and initiative in close touch with actual operations. In war, urgent problems and difficulties arise, sometimes suddenly, which an experienced scientist can recognise as capable of scientific treatment, which other people cannot. In a war waged at the speed of the present one, grave damage or disaster may follow failure to tackle an operational problem or difficulty immediately ; great advantage may result from anticipating it. Moreover, new devices, methods, and weapons seldom work perfectly when handed over to the troops. If their full usefulness is to be achieved they must be nursed through their teething troubles by people who understand them, and the tactics and strategy of their employment must be worked out by ' users ' and scientists in collaboration.

This does not imply that scientists need set themselves up as experts in strategy. It does mean, and it has meant, that very serious harm indeed may be done by failure to bring science into contact with the actual user, and with operations, at all stages. It is a grave mistake to put scientists and soldiers into separate water-tight compartments. The former are not just superior technicians paid to dish up the magic which the latter in their superior wisdom order. There should be continual and instant collaboration up to the highest level in the common task of applying all the resources of science and technology to frustrating the knavish tricks of the enemy and prosecuting our own initiative against him.

Perhaps I may interpolate here that although the principle that the scientist should be in direct contact with the ' user,' or with ' operations,' applies literally only to weapons and methods of

war, it is, in fact, universally applicable. War happens at the moment to be the most urgent example, but throughout all the applications of science, whether to war, to government, or to industry, the same principle applies. The scientist, the specialist, should not remain for ever in his laboratory ; there, no doubt, is his primary concern, and heaven forbid that scientists should become general busybodies (as for my sins and Hitler's I am forced for the present to be) ; but unless he looks outside his own little wood sometimes he will fail to see the wood for the trees, or to understand the relation of his task to the bigger tasks of the world. In whatever sphere of human activity his work has application, the scientist should be in touch with the ' user,' the ' user ' in touch with the scientist. So only can science in government, or science in industry, or science in human affairs, fulfil its desired rôle.

So much, then, for research in Service or Supply Departments. In many other departments of government, however, there is need of scientific consultation, scientific foresight, and scientific criticism. In these also, unless experienced scientific people are available to keep in touch with their everyday work, scientific problems or opportunities may never be realised as such until too late. Permanent officials with a scientific education can meet part of the need ; but not all of it, for they are bound to become rusty in their offices, and anyhow the people with the keenest and most original minds are not usually inclined to become officials at all. The advice of outside scientists is necessary.

Some departments act on this principle, but not all of them. Sometimes even those that profess to do so specialise rather in figureheads, seeking more to be able to answer questions in the House with a display of famous names than really to seek up-to-date scientific advice. One department, for example, when recently questioned, proudly named an adviser aged eighty-six years. It is important that every department in which science in its widest sense can find application should be accessible to independent scientific advice. It is not necessary—indeed, it would be absurd—to ask that an organisation of the magnitude of the Scientific Advisory Council of the Ministry of Supply should be set up in every department ; but a panel of two or three independent advisers at least is necessary if opportunities are not to be missed. This panel should have a recognised status, and reappointments should be made to it every few years in order to ensure that the system —and the scientists—are really alive.

In this country we do not believe in bureaucracy. Our national genius has evolved a system by which the activities of officials are continually subject to the advice and help and criticism of public-spirited citizens. The wise officials appreciate this ; the stupid ones do not. Let us never abandon this principle, otherwise, with our traditions, we are in for a long spell of trouble. Let us rather praise and extend it, whatever our totalitarian youth may say. One way to extend it is to insist that independent scientific advice shall be given a constitutional place, and a constitutional right to be heard, in government departments.

Even, however, if departments were saturated with scientific advice, it would still be necessary to ensure that the Cabinet itself should be properly served. The Scientific Advisory Committee and the Engineering Advisory Committee, both under the chairmanship of Lord Hankey, now fulfil that function here. The arrangement is new, but undoubtedly it works well. Dealing as they do with the reactions of science and technology with policy, at present particularly but not exclusively in connection with the war, the Committees cannot busy themselves with details which naturally go to departmental bodies, and most of their activities cannot in wartime be publicly described. The Chairman, as a Minister of high rank, working under the Lord President of the Council, who is the member of the War Cabinet primarily responsible for research, has access to all Ministers and Departments. A new link has thus been forged, and science at last is in contact with the centre of government.

In the United States a similar link exists. The Director of the Office of Scientific Research and Development in Washington is directly responsible to the President. Under this organisation come the National Defence Research Committee, the National Advisory Committee for Aeronautics, and the Medical Division of the National Research Council. This arrangement is quite new, and in many ways different from our own ; but it is like it in the sense that in the United States, as here, science now has direct access to the centre of government. May it so continue in both countries !

I have dealt with the attitude of mind from which the problems of science in government must be approached, and with the organisation needed at departmental and Cabinet level. It remains now to deal with the scientists themselves and the problem of how to keep them alive. It is essential, if the scientific minds of the scientists in Government employment are to be saved from sterility, and their souls perhaps from damnation, that there should be as little distinction as possible between them and those in the universities, in industry, and in other independent institutions. In wartime there is little distinction ; we are all in it together. What I say applies to the more normal times of peace.

Government scientific employment in general has certain characteristics :

(1) It has security of tenure, fixed hours of work, regular promotion, and a pension.

(2) Adequate equipment is usually available, and there is not a continual struggle for funds.

(3) The object and direction of investigation are usually laid down by authority.

(4) Discussion and publication are usually limited, sometimes because of the real or alleged necessity of secrecy, often simply by tradition.

(5) Teaching duties generally do not exist, and there is often no necessity to follow the scientific literature except in a special field, with the result that interests are likely to become narrow.

(6) Attendance at meetings of learned societies, conferences and congresses, the holding of colloquia and discussion meetings, and contacts with scientists in other fields are rare.

(7) Visiting workers, particularly foreign workers, are few or absent altogether.

For such reasons, unless a man has exceptional ambition and originality, his initiative and keen-

ness tend to be blunted. There are several ways to avoid this :

(*a*) To ensure that directors of research, heads of laboratories, &c., are people of exceptional quality, not only in ability, originality, and experience, but also in their human relations and sympathy. Such men in such positions are rare, but they exist ; their value is very great. It is essential that they should remain investigators at heart, and as far as possible in action, and not become mere bureaucrats.

(*b*) To adopt a common pension scheme, similar to that of the Federated Universities System, with the universities, with industrial laboratories, and with all institutions in which scientific work is done.

(*c*) To encourage junior and senior workers alike to interchange freely with other departments, with industrial laboratories, or with universities.

(*d*) To provide facilities for visiting workers, for colloquia and discussion meetings, and for attendance at meetings of learned societies.

(*e*) To adopt a system analogous to that of the reserve of officers and other ranks by which the Fighting Services prepare for times of emergency. Many of the ablest workers elsewhere would rightly value a period of service in Government laboratories, although not prepared to devote the whole of their lives to it. After their period of service, they would return to their chosen jobs in universities and other places, with occasional ' refresher ' periods later.

I have urged before that this system of building up a reserve of scientific officers should be adopted as soon as normal conditions return. It would be the greatest pity if the many able men who have done such excellent service in Government establishments should then lose touch permanently. Widespread support of this proposal has been evident. It has many advantages ; sudden expansion in emergency would be much easier, the universities and other institutions would be kept in touch with Government scientific establishments, and *vice versa*, those who joined the Government service would not be permanently isolated from the scientific workers outside, and the highly interesting and important work which is done in Government laboratories would be more commonly appreciated and known. By forming such a reserve, the intellectual status and the fruitfulness of Government science would inevitably be raised and the universities would be brought into closer touch with realities.

There is no need to go into details ; they can be settled later. The broad principle is that in every way we need to break down barriers between universities, independent research institutions, industrial laboratories, and the scientific establishments and service of the Government. This can be done by regular interchange of personnel, by a common pension system, by providing in the Government laboratories all those facilities for discussion, for meetings, for criticism, for initiative, for collaboration—even perhaps for teaching—which are found elsewhere. We must not be deterred in this project by bureaucratic objections, by false economy, by the red-herring of secrecy, or by alleged administrative difficulties. In science also we must deliberately follow the line of our national genius, and ensure the fullest co-operation and interchange between independent science and science controlled by the State.

This plan for a reserve of officers and for frequent and regular interchange between different kinds of institutions need not be limited to science ; it should be open to the Government service as a whole. Drastic changes are needed in the Civil Service. Personal ability and personal integrity, essential as they are, are not sufficient ; the outlook, the methods, the organisation, the traditions of the Civil Service must be altered, and contact must be maintained with the real world and its methods outside. The war has shown, what many suspected already, that for all its devotion and its high traditions, the Civil Service has largely failed ; the same might well be said of Parliament, but that is another matter. Nothing could be better for the Civil Service, for industry, for the universities, than to institute a regular interchange of personnel ; to treat the universities as staff colleges to which workers from the Civil Service, or from industry, return at intervals for refreshment ; to treat industry and the Civil Service as the workshops in which for a period university dons can obtain practical experience ; to give to Government offices a touch with reality, and to industry a touch with national needs, by the mutual temporary interchange of some of the ablest men on either side. We are concerned here to-day primarily with science in government. Science, however, will never be given full scope until a revolution has occurred in the methods and outlook of government itself.

May I finish on a note, not of criticism but of hope ? Under the old regime of *laissez faire*, which we intend that the proper use of science in government shall replace, our public health services were organised mainly on the principle of trying to cure people when they were sick, our architecture on mending the pipes when they burst after a frost, our industry on paying people a dole when they were unemployed, our national defence on getting ready when a war had begun. It is obvious, however, that scientific planning and the planning of our national resources can make many of our troubles unnecessary. By designing our houses properly the pipes need never get frozen up ; by proper attention to nutrition, to public health and physical education, sickness can be largely avoided ; by deliberate planning of public works, unemployment can be greatly reduced and the standard of living raised ; by adopting a period of national service, universal for men and women alike, as the highest form of democracy, we can avoid blundering unprepared again into war, and can add a new dignity to our citizenship. Scientific planning, and planning with the aid of science, are what we look forward to ; planning, however, in which any new order we arrive at is fitted to our traditional freedom.

Prof. Luther Gulick

Large-scale Planning as illustrated by the T.V.A.

No man can stand on the soil of England after years of absence without paying tribute to what he finds here in the example of courage, not only the courage of moral fibre, but the courage of imagination, of intellect, that reaches forward into the world that we hope to build when this

assault on our freedom and our progress is over. I suppose that when we are gathered to consider the contribution which men of science can make it is highly appropriate that we should consider also the practical problems of administration with which we are faced, and therefore I am emboldened to bring forward this account of a most imaginative and successful experiment in my own country—one which has been called America's most imaginative and most successful domestic accomplishment of the past decade, the Tennessee Valley Authority, or, as we call it, the T.V.A.

Roughly following the southern Atlantic seaboard of the United States and 250 to 300 miles from the shore is the Appalachian Mountain Range. Another 40 to 80 miles west rises the parallel range of the Cumberland Mountains. Between these 4,000 to 6,000-foot elevations lies the Tennessee Valley. When the mountains run out to the south and west in Alabama and Georgia, the valley turns west and north and runs into the Ohio and Mississippi valleys.

The valley of the Tennessee is shaped like a man's arm : the shoulder is in Virginia and West Virginia ; the upper arm in eastern Tennessee and western North Carolina ; the elbow in Alabama ; the forearm in Tennessee and the fist in Kentucky. It is 300 miles from shoulder to elbow and 350 miles from elbow to hand.

The white man made the problem of this area for himself by cutting off the trees and farming the clearings. The rainfall of this valley is 52 inches a year, with as much as 80 inches in the upper reaches. With the trees gone, all of this water, 6,000 tons per acre per year, rushes to the river and the river rushes to the sea, carrying with it the farmer's precious top soil and spreading destruction in the towns and villages and cities which are naturally drawn to the river side by commerce. Each small landowner acting ' prudently ' to raise his own income succeeded, over the generations, in undermining the whole area and thus himself too.

This part of the United States has abundant natural resources. It still has timber and rich land ; it has in Alabama 800,000,000 tons of iron ore. There are coal, petroleum, chemicals, pigments, abrasives, fertiliser ingredients and ceramic and aluminium clays.

The area of this valley is 26,000,000 acres, about the size of England, but with all its potential wealth it supports only 2,000,000 people, at an average standard below that for the United States. In some sections the average family income was less than $100 a year.

Another aspect of the problem is purely governmental. The boundaries of our states in this area were laid out partly in London by Royal grants, partly before 1789 by colonial legislatures and partly by subsequent acts and agreements. States, which call themselves sovereign, were set up and in the valley alone 100 counties were carved out without any consideration for the major problem which now confronts the area and its population. And thus being unable to get organised to deal with its problem, the people of the area were inevitably sinking, condemned either to outside exploitation or to progressive deterioration in the face of a potentially rich economy.

The Federal Government entered this picture over a century ago when President Monroe, whom you know more for his foreign policies, advocated the improvement of the Tennessee River for navigation ; but nothing was accomplished.

The problem of floods, increasing in their severity, led to heavy protective expenditures by the Federal Government for over 100 years, mostly further along in the Ohio and Mississippi rivers, in the hope that dikes, levees and spillways would tame these rivers. But about once a decade the rivers have broken loose again. A flood in 1927 drove 700,000 people from their homes.

About the turn of the century came the interest in water power. In 1903 an important policy was established by President Theodore Roosevelt when he vetoed a Congressional Act which authorised a private hydroelectric plant on the Tennessee because he believed that power development should go hand in hand with and support navigation, the control of which, under our Constitution, is an exclusive power of the national government.

The need for electric power to produce nitrates during the last World War brought the first real forward step. It was thus under President Woodrow Wilson in 1917 that the great dam and the nitrate plants at Muscle Shoals were started.

Then followed more floods and fourteen years of debate, destruction and inaction—until Franklin D. Roosevelt was elected in 1932. One of his early messages to Congress was that of April 10, 1933. In this he said :

' It is clear that the Muscle Shoals development is but a small part of the potential public usefulness of the entire Tennessee River. Such use, if envisioned in its entirety, transcends mere power development ; it enters the wide fields of flood control, soil erosion, afforestation, elimination from agricultural use of marginal lands, and distribution and diversification of industry. In short, this power development of war days leads logically to national planning for a complete river watershed involving many States and the future lives and welfare of millions. It touches and gives life to all forms of human concern.

' I therefore suggest to the Congress legislation to create a Tennessee Valley Authority—a corporation clothed with the power of government but possessed of the flexibility and initiative of a private enterprise. It should be charged with the broadest duty of planning for the proper use, conservation and development of the natural resources of the Tennessee River drainage basin and its adjoining territory for the general social and economic welfare of the Nation.'

The recommended Act was passed in a month and the Herculean task of administration began —a task made the more difficult because under our system all important measures must also run the gauntlet of the courts on constitutional grounds. Within five years there were forty-one such cases, two of which were carried through to the Supreme Court, where the T.V.A. was upheld on all counts. It was firmly established that the Federal Government has the power through such an agency as the T.V.A. to use twentieth-century science and technology to cope

with needs which are too big for individuals and local governments to handle singly or collectively.

While these decisions were on the way, the work went ahead. The T.V.A.'s first job was to bring the Tennessee River under control. This is being accomplished by means of a series of high dams to convert the 650 miles of main stream into a chain of connecting lakes, extending from the mouth of the river at Paducah, Kentucky, to its source at Knoxville, Tennessee. Six main river dams, including Wilson—received from the War Department—and Hales Bar—purchased from the Tennessee Electric Power Company—have been completed and are now in operation. Three more dams, now well under way and all scheduled for completion by the middle of 1944, will round out the construction programme in the main river channel.

Up the valleys of the feeder rivers that empty into the Tennessee, storage dams are being constructed that trap and hold back enormous reserves of water for controlled release. Two tributary dams have been completed and are now in operation. Five more are under construction, all of which are scheduled for completion by the end of 1943. All T.V.A. dams, tributary as well as main river, are designed and operated for multiple purposes—to facilitate navigation, to permit storage and control of floodwaters, and to produce cheap hydroelectric power.

An improved and greatly extended navigation channel has made possible a growth in commercial traffic on the Tennessee River from 25 million ton-miles in 1933 to 83 million ton-miles in 1940. By 1944, it is estimated, shipping will have grown to 500 million ton-miles.

In the fight against floods, approximately 4 million acre-feet of controlled storage has already been provided. When the projects under construction are completed in 1944, the system will provide for more than 11 million acre-feet—sufficient capacity to impound the Tennessee until the flood crest on the Mississippi has passed beyond the point of confluence.

Installed generating capacity, including standby steam plants as well as hydro plants, now exceeds one million kw. By 1944, installed capacity will have been increased to two million kw. Energy output for the fiscal year 1941 amounted to approximately 6,000 million kw.h., raising T.V.A. to sixth place among the large power systems of the United States.

In disposing of power generated at its multiple-purpose plants, T.V.A. occupies the position of wholesaler. Its customers include, in addition to several large industrial concerns, 76 municipalities and 38 non-profit co-operative distributing systems that resell T.V.A. power to about 450,000 residential, commercial, and industrial customers at rates a little more than half the average rate for the country as a whole. Total sales for the fiscal year 1941 amounted to 5,000 million kw.h.

Power, unlike flood control and a navigable channel, can more than pay its own way. Congress, therefore, adopted the view that although electric energy is an essential service to be made widely and cheaply available, it should nevertheless help to pay the cost of developing the Tennessee River for other potential uses.

During the fiscal year ending June 39, 1941, T.V.A. gross revenues from power sales amounted to $21,000,000. This sum is more than sufficient to cover all operating expenses connected with all of the Authority's programme, not only in the river channel but throughout the region as a whole.

Eight years of T.V.A. experience has shown that, in the case of public power, the consumer's interest in low rates and the taxpayer's interest in a reasonable return on his government's investment are not incompatible—that low rates, in short, are good business.

But the flood control, the navigation and the power programmes are not the whole story of the T.V.A. The most important aspects are found in the parallel social programme, in the decentralised democratic and co-operative techniques which have been followed in the administration of the T.V.A., and in its use of scientists.

The social programme was partly a matter of good business and partly a matter of social vision. The latter is evident in the effort to improve housing, education, health, recreation, farming techniques, transport and the standard of living generally ; to introduce refrigeration, rural electrification and diversified industry, and the sharp reduction of electrical rates and of the initial cost of electrical appliances. These social measures are at the same time ' good business ' because the area cannot use 2,000 million kw. without more industry, more population and a far higher standard of living than that with which the valley started in 1933.

A second factor of significance is the technique of administration. In the T.V.A. we have a regional corporate agency, cutting across the old jurisdictional lines and following the geographic lines of its central problem—which in this case is the watershed, the uncontrollable run-off of heavy rainfall. The powers of this authority do not stop with the engineering problems involved but include responsibility for looking ahead to see how the balance of nature and of society may be disturbed by the programme, to make plans for dealing with the situation, and to see that those plans are carried out by existing public and private agencies or by the Authority itself.

Thus, while the T.V.A. is above the seven states and the 100 counties which it embraces, it does not supersede them. And while it is in its area the most direct representative of the Federal Government, it does not take the place of the regular services of Agriculture, Interior, Public Health, etc. But the T.V.A. does give an entirely new focus for all these agencies at the planning and co-ordinating level.

Persuasion rather than edict and power also characterises the relations of the T.V.A. with the governments, the corporations, and the farmers of the area. Demonstrations in the use of T.V.A. fertiliser and modern farming, now going forward on a scientific basis on 20,000 farms, are arranged after farm neighbourhood meetings with the county agricultural agent and the selection of the demonstration farm by the neighbours.

Without legal power to proceed the T.V.A.

could not have gone ahead with its work in flood control, navigation, power generation and manufacture of nitrates—but the absence of power to execute except by consent and co-operation in the other areas has been productive of some of the T.V.A.'s most impressive achievements.

A third factor of importance is the extraordinary extent to which the scientist and technician have been relied on in this whole undertaking. The T.V.A. has spared no effort to draw into its work not only leading engineers but also leading social scientists. This has been done especially at the stage of analysis and planning.

Ten years from now, with a continuance of these policies and approach, the Tennessee Valley will present one of the most striking planned evolutions in social history. Through the harnessing of wild rivers, the restoration of depleted soil, the afforestation of mountains, the influx and decentralisation of industry and through intelligent, conscious and planned co-operation of the people of the area, the average income will certainly be more than doubled. The last dams will be completed in 1944. Within six years the sale of electricity alone will exceed 12,000 million kw.h., and the revenues at one-half the average American power rate will meet all the costs of generation and pay a reasonable return on the investment. And that will be the beginning and not the end of this experiment in raising the standards of life by planning, co-operation, the application of science, and the fuller use of human and natural resources. And what is more, the T.V.A. has already taught the country that in the electricity business (public and private) there is more profit for all with a policy of low rates and high consumption than with the past practice of scarcity and high prices. This alone justifies T.V.A. if further justification were needed.

This description of the work and operation of the T.V.A. concludes my second point. Though I have left much unsaid and have said nothing at all about its present contribution to the War, I hope this outline gives you some idea of the T.V.A. You will see that it is an integrated, decentralised regional, democratic agency for planning, executing and administering not only a great series of multipurpose engineering works, but also for dealing with the social and economic problems which are involved within the framework of a system of free enterprise and free elections.

I thus turn to my last point : ' What may we as social scientists learn from this experiment even at this early stage ? '

(1) Definable regional problems requiring novel and integrated treatment yield more readily to regional agencies of planning and execution than to central governmental agencies.

(2) The purposes of a regional authority require clear but broad definition and broad grants of power from the central political authorities. The selection of methods, the co-ordination of details, the subdivision of budgets must be left in the broadest terms to the regional authority so that it may have a free hand in experimentation, invention, and the full use of technology and science.

(3) Planning, i.e. the co-ordinated development of policy within the objective set, is the foundation of success in such an enterprise and must be woven into the process of administration. It is at this point especially that men of science can make their contribution.

(4) Such planning is not only compatible with a democratic system of multiple parties, free elections, free criticism, free discussion, free enterprise and private capitalism, but it is essential in releasing the energies of freely co-operating individuals and governmental and private corporations in fulfilment of plans and objectives.

(5) The corporate device with power to make public and private contracts is an effective instrument for dealing with a regional problem and can be superimposed on, subimposed under and work with previously existing governmental structures without necessitating their abandonment.

(6) The greatest contribution of such a regional agency is in planning, co-ordination and leadership. Its powers, organisation and personnel should be chosen to fit these concepts.

Men of science have made their contribution to this enterprise not so much as administrators or as critics, but as collaborators in the planning agencies and councils of the T.V.A.

It is not for me, at this conference, to apply to other areas of the earth the lessons of the T.V.A. When peace returns, we shall again tackle the rebuilding of our world. This time we of the New World will participate. In doing so we shall hope that the demarcations of planning and of administrative power may follow the boundaries of problems and that planning will precede action so that science and technology may be brought more fully to the service of mankind.

Dr. P. W. Kuo, Ph.D., LL.D.
Promotion and Application of Science in the Government of China

CHINESE appreciation of Western science in its modern form was first evidenced by the attempts made to introduce reforms in the time-honoured examination system, which was the means of recruiting candidates for the government service. As early as the year 1869 the Viceroy of the Fukien province memorialised the throne, suggesting that a knowledge of mathematics should be required of candidates competing for degrees in the examinations. In 1875 Li Hung Chang, then Viceroy of the Chili province, presented a similar memorial recommending the introduction of physical science as well as mathematics among the subjects of examination. Both of these recommendations, however, failed to receive the Imperial sanction, showing that the time was not yet ripe for the change. But, while the Government was reluctant to modify the examination system, the new learning was gaining in popularity with the more progressive *literati* of the country. Finally, in 1887, two years after the close of the war with France, the Government, now fully convinced of the necessity of reforming the examination system, decreed that mathematics and science be introduced in the government examinations, and for the first time in Chinese history modern sciences were placed on a par with classical learning. Owing to the fact, however, that the literary chancellors who presided over the examinations were unfamiliar with the new learning, very little was actually accomplished. Nevertheless, the step taken was of

great significance. A writer of the time, commenting upon the reform thus introduced, remarked that the thin edge of the wedge had been driven into the examination system, which in the end will rive asunder the old wall of Chinese conservatism, liberalising the minds of the *literati* and setting them forward in the path of progress and reform.

Soon after the last war with Japan, Chang Chih-Tung, then Viceroy of the Hupeh and Hunan provinces, advocated in a remarkable book the establishment of modern schools and universities throughout the country, and the inclusion in their curriculum the teaching of science. China's first modern educational system, however, was not created until 1903, and the examination system was not abolished until 1905. The system of education, reorganised after the establishment of the Republic in 1911, gave greater emphasis to science, shown by the fact that the time formerly allocated to Chinese literature was greatly reduced in order to give room for the more liberal introduction of scientific studies which required the use of the laboratory or experimental method. This new emphasis on science was undoubtedly due to the belief of our leaders that most of the modern progress in government, finance, industry and commerce has been accomplished in other countries by the use of scientific knowledge and methods and that the new generation of China must be given a training in science in order to insure the ultimate success of the Chinese Republic. During the two decades which followed, the promotion of science in China made considerable progress.

In the early stages of the Sino-Japanese war, the Japanese army and air force made deliberate attacks upon educational institutions, aiming at their total destruction. As a result many of the leading institutions of learning were destroyed and the movement to encourage science suffered a temporary setback. Realising the importance of education, thousands of students and professors migrated from coastal regions to the south-western and north-western provinces and built up new institutions of learning with a view to meeting the needs of national resistance and reconstruction. And now, after four years of war, China's educational institutions have grown in quantity and improved in quality.

Of special interest is the fact that in recent years there has been a growing tendency among the students to take up the study of natural science, whereas in previous years the study of arts and social sciences was more popular. The year 1937, when the Sino-Japanese conflict began, marked a turning point in this tendency. In that year the total number of science students approximately equalled that of non-science students, whereas in previous years science students represented on the average only a fourth of all university students. This increased interest in science is due partly to the readjustment of college courses on account of the war, and partly to the recognition of the importance of industrialisation and to the rapid development of modern industries.

Although education has been the most potent factor in the promotion of science in China, there are other institutions at work, each contributing its share of influence. The most important of these institutions is the National Academy or Academia Sinica, founded in 1928 with the twofold purpose of prosecuting scientific researches and of promoting and co-ordinating research programmes in the country. It has established ten institutes for the following branches of science, namely : astronomy, meteorology, geology, physics, chemistry, engineering, psychology, mathematics, history and philology, and social sciences. Each institute maintains a number of research fellows, associates and assistants to carry on assigned investigation and experimentation under the general guidance of a director.

Time permits the mere mention of the names of some of the other institutions or organisations interested in or devoted to science, namely :

Chinese Economic Society.
Chinese Engineering Society.
Chinese Institutes of Mining and Metallurgy.
Chinese Society of Chemical Industries.
Chinese Sociological Society.
Chinese Statistical Society.
Fan Memorial Institute of Biology.
Mathematical Society of China.
Philosophy and Science Research Association.
Société d'Agriculture de la Chine Nouvelle.
Société Astronomique de Chine.
Société Météorologique de Chine.

Let us now turn our attention to the application of science in the government of China. First of all let us note the influence of scientific methods in China's finance. On the eve of the Sino-Japanese war, China's monetary system was being transformed and modernised through the reform of her currency system, the evolution of budgetary control, the adoption of direct taxation, the consolidation of her internal taxes and the rehabilitation of her national credits.

Since the outbreak of the war the National Government has adopted measures to minimise the flight of capital, to control foreign exchange, to supervise the money market, to regulate import trade, to encourage exports, to prevent undue rise of commodity prices, to increase loan and credit facilities in the interior, and has organised the Currency Stabilisation Board in co-operation with the British and American Governments. It is a generally recognised fact that the strength of China's stubborn resistance must be attributed to a large extent to the efficient manner in which the country's economic and financial structure has been consolidated and kept intact.

Another activity of the Chinese Government in which the influence of science has been felt is the Foreign Trade Commission. According to Dr. H. H. Kung, Vice-President of the Executive Yuan and Minister of Finance, China's foreign trade during the past three years has been marked by four distinct characteristics. They are : laying the foundation of China's foreign trade, nationalising commerce with other countries, encouraging production of exports through the use of scientific methods and fulfilling China's loan obligations to foreign nations. In an effort to multiply the products of China, the Commission has adopted a five-years' programme to increase the exports of wood-oil, tea, silk, wool, seeds and handicraft products through the use of scientific methods, sponsored by the National Agricultural Research Bureau and the agricultural experimental stations in various provinces.

Transportation and communication represent China's urgent problems. In spite of the war, the Ministry of Communications has brought about increased facilities and greater efficiency in China's modern ways of communication, including the telegraph and telephone, the radio, the railways, the air services and the highways. The progress made in the extension of modern highways is undoubtedly the most significant. The building of the Burma Road, covering a distance of about 1,300 miles, is generally regarded as an engineering feat. According to the estimate of British and French experts it should have taken at least three years to complete, but China built it in seven months. Chinese highways in the north-west to-day link British Burma in the south and Soviet Russia in the north, as it is possible to travel overland through China from Lashio on the Chinese-Burma border and to Tacheng on the Chinese-Soviet border. In spite of the difficulties of securing sufficient automobile spare parts and supplies, Chinese engineers have been able to keep this network of transportation and travel at a high level of efficiency.

This extension of modern ways of communication has enabled China to import necessary materials for the conduct of war and to export her products for providing the means of payment, thus making possible China's continued resistance against Japanese aggression. By bringing the distant provinces into closer touch with each other it has also brought about greater unity among the people. It has made easy the maintenance of order and further strengthened the authority of the National Government.

The Ministry of Economic Affairs, which is headed by a well-known geologist, Dr. Wong Wen-Hao, is permeated with a scientific spirit. It conducts several bureaux for the inspection and testing of commercial commodities, which resulted in the standardisation of China's exports and the establishment of confidence in foreign markets. Through the National Bureau of Industrial Research, improvements in mining processes have been made, resulting in the increase of mineral products such as wolfram, antimony, tin, etc., making possible the repayment of credits from America, Russia and Great Britain. The Ministry also conducts under its auspices the National Geological Survey, the National Resources Commission, the Industrial and Mining Adjustment Commission, and other departments of a scientific nature.

The effect of science on the activities of the Ministry of Agriculture is seen in the efforts that are being made to increase the value of China's exports by improving the seeds of cotton, wheat, rice and other agricultural products. It is also shown in the successful control of insects, in the improvement of fertilisers and of farming implements. The Ministry is also taking every step to improve animal husbandry through scientific breeding and cross-breeding.

In the field of social welfare, the influence of science is clearly shown in the activities of the Ministry of Social Welfare, the National Health Administration, the Chinese Industrial Co-Operatives, the National Relief Commission and many other departments or organisations working for the relief of the suffering and the enhancement of human happiness.

In the presence of such an international gathering, it seems only appropriate for me to state that in the efforts undertaken by the Chinese Government to utilise science and scientific methods towards the creation of a modern and efficient Government, the friendly Powers and their nationals have rendered valuable assistance. The Rockefeller Foundation gave handsome donations towards subsidising the erection of science halls and the creation of science professorships in the National South-Eastern University and the Nankai University. The China Foundation for Education and Culture and the Sino-British Indemnity Board have also promoted science through the creation of scholarships and fellowships for the study of scientific subjects.

The British Economic Mission to China, headed by Sir Frederick Leith-Ross, made valuable contributions towards the reorganisation of the Chinese currency system. British and American nationals in the service of the Chinese Government have rendered useful services in finance, in railway construction, in postal and customs services as well as in the salt gabelle. During the past two years the United States Government has sent two missions of highways experts to assist China in her efforts to improve her system of highways, including the Burma Road. The co-operation and assistance so rendered are deeply appreciated by our Government and by our people.

From this brief survey of the steps taken in the promotion and application of science in the Government of China, it is clear that modern science has made considerable progress in that country and has played an important part towards the evolution of a modern and efficient Government under the able and inspiring leadership of Generalissimo Chiang Kai-Shek. There is no doubt that as time goes on it is bound to make valuable contributions towards the solution of China's manifold problems created by the war as well as problems of post-war reconstruction. For the time being China is predominantly an agricultural country and her natural resources remain more or less undeveloped. The application of scientific methods to her agriculture and industry will enable her to multiply her raw materials which she possesses in great abundance. This will not only solve China's own economic problems but will also enable her to make available her surplus resources to the rest of the world. This, however, will not be possible if she should be dominated over or exploited by one aggressive power to the exclusion of other nations.

In closing, may I say that China intends to make the best use of science and its possibilities. It is our belief that the mission of science is not to destroy, but to create ; not to increase human suffering, but to enhance human happiness. I can assure you that Chinese scientists being imbued with the spirit of service stand ready to co-operate with scientists of other countries towards the creation of a new world in which the benefits of science will be made available for all peoples.

Prof. J. D. Bernal, F.R.S.
The Function of the Scientist in Government Policy and Administration

In this war, as never before, the dependence of government on science is made manifest. But it is

only in their apparent urgency that the needs of war differ from the needs of peace. What science has given to war for the destruction of humanity it can give more effectively and more willingly for its benefit. The experience of war shows clearly what before had only been tentatively guessed at, that in the modern world only organised activity counts and that no activity can be organised effectively unless it is done scientifically.

The first gifts, for good or ill, that science brought to humanity are the more obvious mechanical and chemical inventions—cheap power, great mobility, rapid communication, new materials. But we are now beginning to see that more important than all of these is the new way of doing things which has grown up with the practice of science, and is now spreading into all fields of human activity. Science as measurement, science as organised common sense, is now everywhere coming into its own.

We are in the middle of a complete transformation of the position of science in social affairs. The actual conditions of war have speeded up that transformation and have made possible developments that might, before the war, have taken many years, and we can now see that science has got a far wider and more thorough-going application to governmental affairs than had previously been accepted or even imagined.

Many people—especially civil servants—are apt to think that the scientist is a purely advisory factor in administration. He is useful because occasionally problems — usually comparatively trivial technical problems—turn up to which it is not possible to get a satisfactory answer without consulting the scientist who knows about this or that technique. The scientist is asked for his advice, he gives it, and the administrator, using or ignoring it, frames his policy and carries it out. That method has already broken down and is being replaced by another in which science is extending its scope throughout the government machine. In particular two other functions of government are being increasingly permeated by science. One is in deciding the direction in which policy shall go, and the other is in the actual carrying out of the policy itself. Professor Gulick has given us a very complete example of how a problem previously defined can be solved by the technicians and scientists in an integrated way. But what we are coming across now is the task of defining those problems. One reason why the problem of the Tennessee Valley could be defined so accurately is on account of the many years of inaction and disaster that preceded the setting up of the Tennessee Valley Authority.

In conditions of war we have not that leisure to discover what our problems are. Disaster comes too rapidly in wartime, and the job is to anticipate disaster rather than to react after it. For that it is necessary to supplement existing methods of determining what the problems are by scientific means. It is necessary, in the first place, to make a scientific survey of the field of needs and to make that survey rapidly and effectively. The experience of this war has already shown that this is quite possible and can be successfully carried through. We have given to us, very largely through commercial developments but also through the development of scientific agriculture, new methods of statistical analysis and sampling that enable us to find out to any degree of accuracy required, and in as short a time as we have at our disposal, enough information on which to base action.

In the past government statistics have been thought of rather as historical data. By an exhaustive enumeration, as in a census, the facts of the situation are recorded for the benefit of posterity. But there are now far more rapid ways of doing this, and we can tell roughly what the situation is within a week so that action can be carried out in the week following. It is true that we have not got accuracy to seven figures, but without a snap survey action has to be taken with no figures at all, and even one figure arrived at roughly marks an enormous improvement, mathematically an infinite gain. We are able to survey the situation now in this way and to determine from such a survey what the problems really are.

The discovery and determination of the limits of current problems is a most important new function of science. When those problems are sorted out it will generally be found that most of them have in principle been solved somewhere else by someone else, and it is a matter of getting in touch with the right people to indicate how to apply the solution to the particular case. There is a serious gap here in the failure of most of our information services to keep people in touch with existing knowledge. Modern methods of documentation, however, such as all the devices of filing, sorting and the micro-film, are providing new means of making information instantly available to people who want it, and, going beyond that, giving people the information they ought to have before they even knew that it existed or that they wanted it. This is a positive service of information which has arisen out of the work of the librarians during the years before the war, and it is going to be one of the most important features in building up a new world. But, obviously, all the problems will not have been already solved. There will be many that will be new, and will have to be worked out by straightforward research methods, and this is the function of the research departments. Lord Samuel and Professor Hill have said something of the range of problems they cover in wartime. I should go further than that, and say that we still need, and will need very much more for the new world, a much greater organisation and collaboration between research departments. This is not only because there are far more problems than we have facilities to deal with, but because there is one feature that has not possibly been sufficiently recognised in the past. Scientific researches cannot be simply classified. Each research falls into two distinct sets of relations, the sets of the research users and the sets of the research producers. Any large administrative body will require research coming from many different sources, and any research body, such as an institute for research in metals, for example, will be giving information to many completely diverse departments of State. Where we have lacked co-ordination in the past is in linking those two together, and for this we require a much more thorough and a much more flexible research organisation.

From the question of research we can pass to

one which is not new but again requires great improvement and a new attitude, and that is development. It was calculated in an American report some years ago that the average period between the first appearance of an idea in an explicit form in the human mind and its incorporation in an article or process of common use averaged 150 years. That period has been considerably shortened, but most practical people will still tell us that it is something in the neighbourhood of ten years. In my opinion that period is too long by a factor of between 5 and 10, and the reason is that we have not attempted to get a rational drive into development. The 150 years' periods were largely spent in waiting for people with specific needs or money to finance the development. To take a simple example of recent times, the zipp fastener existed in a complete form for fifteen years before anyone could be got to take it up.

Another kind of lag is due to the isolated way in which development is carried on and to its separation from research. Development and research can now be united ; this is being done more and more extensively in government and war laboratories, so that the process of getting from the laboratory into the field or workshop can be immediately shortened by close co-operation between the laboratory scientists, the developmental planners, the production engineers, and the actual manufacturers and workpeople. We need the extensive use of factory research stations and experimental factories as Dr. Labarthe points out. In this way invention and production can be integrated and pushed forward much more rapidly.

But when we have got new implements and weapons we shall still have only just begun the problem of full utilisation of products. We have to learn how to use them to best effect. The new advantages of science are going to be very much more in the use of things even than in their production. I will not dwell on the importance of operational research, which has been adequately dealt with by Professor Hill, but I would say this, that operational research is not confined to wartime operations, but is just as important in every form of peace-time development. In health, in nutrition, in agriculture, everything has to be watched in the field of competent scientists, new problems discovered as they occur, and new remedies made for them at the same time. The integration between operational research and development has to be made complete. This means, in effect, that the executive function of administration has also to be scientific. Somehow the executive and the scientist have to be combined in one person or in a closely acting group.

Finally, we have the question of control. We want to see not only whether the measures taken have been successful in their original intention, but also whether they have other effects not foreseen or thought of when they were introduced. We want a permanent technically qualified body to examine what has been the result of all measures in Government administration during past years and to pick out the difficulties and the new possibilities that arise out of them. With such an integrated body of information, research, development, execution, and control we have the backbone of a scientific administration, one which is scientific through and through and not merely by the addition of a few eminent scientists, and we shall need that for building the world of the future.

Now it must not be imagined that anyone supposes that a general scheme of this sort will automatically transform in a useful way our present administrative system. The functions mentioned are in the first place abstract and formal ; to be effective they must be used intelligently by men capable at the same time of scientific understanding and responsible decision. There is no short cut which can avoid reliance in the last resort on the human element. But—and this is the important point—the ablest administrator, lacking these aids, will in the modern world be both blind and powerless. It is no longer optional to do things in this war as in the old days. Any nation that does so will certainly go under. Militarily, economically and politically, many have already done so. Nor is it sufficient for separate departments of state to be run in this way, unless similar methods are used for the wider integration of all governmental and economic activities. It should be apparent from what has already been written that a general plan, scientifically conceived and executed, is also a necessity. The existence of a general plan has passed out of the realm of controversy into that of accepted expediency. War has brought home to all nations what was apparent in peace in the Soviet Union, that a modern industrial state can only develop if its activities are co-ordinated in a common direction. On the other hand the classical economists had always maintained that planning on a large scale was dangerous, because of the possibilities of immense errors in the distribution of resources, and the absence of automatic checks on profit and loss. Their criticism, however, does not apply to planning as such, but only to unscientific planning. In this age it should be just as possible to plan scientifically for satisfying the immediate and future needs of a community as it is to plan for an individual large firm or department of state. In fact, comprehensive planning should be easier, because the planners do not need to take into account the variations in conditions due to actions taken in other sections. Nevertheless, planning is an immense task, which will occupy the best human abilities for many years to come ; and it must be carried out scientifically. We cannot afford any longer to accept the use of science in detailed and sectional activities, and to refuse it in the general ones. Anarchy or stupidity at the centre has already served to destroy entirely the good effects of detailed excellences in different sections of industry and administration.

It is high time that the best arrangements of the central co-ordinating functions of a modern society should be considered as the most important of the scientific problems that need immediate answers. The solutions could be found in the same way as has been indicated for separate departments. The problems will be of a higher grade, however, in that they will include as component parts the possible solutions reached on the departmental level. Essentially, the problem of planning demands the solution of an equation with many variables representing different ways of expending human effort so as to give the maximum human opportunity for action and the best

biological and sociological environment for humanity.

There is one aspect of general planning that interests us particularly here—the planning of science itself. This used to be a controversial question, but already controversy is fading away before necessities of circumstances, which will remain as great in peace as they were in war. There is, however, a very real problem in the planning of science, greater in some ways than for any other field of human activity. People cannot be ordered to think. If science is planned, it must be on an essentially voluntary and co-operative basis, under the effective control of scientists themselves. There should be no overwhelming difficulty in doing this, now that such a planning has been largely achieved for war purposes in most of the countries of the world, and for peace purposes as well in the Soviet Union. The full utilisation of human intellectual resources can be achieved by building up a flexible organisation with an explicit guarantee of freedom and support for the individual and with encouragement of initiative. But it cannot be too strongly emphasised that an effective planning of science implies a working plan outside science, to which the scientists can give their unqualified allegiance.

The great tragedy of the present day is that science is being used for absolutely destructive purposes, because it is organised and controlled by forces whose very existence is a negation of everything that science stands for. The fate of the German scientists is a warning to us not to accept the once prevalent view that science was concerned merely with means, and not ends. It is very largely the self-imposed limitation of the scientists' viewpoint that has made this possible. From the more general scientific point of view, there is no such thing as separating means from ends. There is one common end—the maximum utilisation of inherent social and individual human capacities—and the necessary condition for this is the providing for all men of the best physiological and social environment. Unless all scientists and all non-scientists alike are working for this end, men will always be in conflict with each other ; and to use their knowledge and ability to negate collectively what each strives for individually, the task of science cannot be separated from the task of humanity as a whole.

After this war, this will be just as true as during it. We must find a common purpose and a new motive which will transcend all the limited motives of private profit or individual security that have dominated men in the past. That motive is already abroad. It is the accepted basis of the heroically struggling Soviet Union, and it is the increasingly widespread feeling in the minds of millions in the major countries of the world, however much suppressed in the Fascist countries themselves. The very existence of the present Congress is proof of its increasing vitality and consciousness.

What we shall need for the new world is a full use of world resources in the service of all men. These resources, we see, are no longer merely material goods, coal mines or wheat fields ; they are far more the internal human and social resources—the resources of ordered intelligence, which is science, and which can teach men how to achieve on an ever-increasing scale complete mastery over their environment ; and the resources of human goodwill embodied in a well ordered social system which can ensure that such mastery is achieved with all speed, and for the common good. But science and human goodwill cannot march separately ; they must go together if they are to escape the futility and destruction of the present day. For this, science must cease to be the preserve of a few people. As the scientist comes more and more to interest himself in all human problems, so must the citizen learn a wider and deeper application of science. If the problem of organisation is the immediate one, the problem of education is in the longer run equally important. The modern state cannot hope to make use of science unless it has a scientifically educated people ; and that education demands a new conception of science teaching. It must relate the achievements of science at every stage of development to the satisfaction of human needs as well as stressing, as before, its inherent experimental and logical basis.

We have come to a stage where we can hope that at last men can be conscious of the working of the society in which they live, and that they need that consciousness to avoid being crushed by the society they had unconsciously developed.

One aspect of this new consciousness is the transformation of state machinery from a tradition-ridden bureaucracy, permanently at loggerheads with an acquisitive industry, into an orderly and scientific organisation for satisfying human needs. I am under no illusion that the transformation can be an easy or painless one, but the very urgency of the situation which makes the change imperative for survival removes at the same time many obstacles that would have seemed insuperable in the past ; and we may still hope to see the change carried out effectively before it is too late.

Prof. J. D. Bernal, F.R.S.

Addendum on an International Resources Office

IN order to give a concrete form to proposals made at the Conference for the international pooling of resources—material, technical, and human—the following draft scheme for an International Resources Office has been prepared. It is in no sense a finished document, but may represent a basis for discussion.

The need for the conservation of national resources has long been recognised. The circumstances of the war make it equally important that resources should be used to the full, and in a co-ordinated way. Both these needs will exist after the war if reconstruction is to be rapid and the resulting world order progressive and stable.

One necessary requirement to achieve these ends is the existence of a body capable of taking a comprehensive view of resources and their utilisation, and of indicating to the appropriate authorities the action most likely to turn them to best account. Such a body must necessarily have from the outset an international character, for without this there can be no check on uncoordinated national developments which, in the past, have led to economic crises and wars. In this sense, it would have a parallel function to the International Labour Office, and might well be called the International Resources Office.

In the modern sense, resources are no longer limited to materials such as minerals, forests or agricultural products. Even more important than these are the techniques by which they are extracted and processed, and the sciences which lead to the further development of these techniques. The International Resources Office would take under its purview the whole of the production flow sheet of modern organised communities, from the mine or field to the ultimate consumer. This may seem an over-ambitious project, but the actions already taken in the organisation of production for the United States, Great Britain and its allies have, to a very considerable extent, covered this field, and all that is needed is a more explicit organisation and fuller co-ordination. These are needed in any case for the more effective carrying out of the war, and if the project is conceived in a sufficiently clear and comprehensive way the foundation thus laid would at the same time form a base in advance for post-war reconstruction.

The main fields of activity of the Office are indicated below :

(1) *Material resources.*—The Office would collate all existing information as to the amount and geographical distribution of material resources, including power resources and agricultural resources. It would further initiate, and possibly finance, surveys to establish the extent of resources not hitherto assessed, particularly in undeveloped countries. All these resources would be considered from the point of view of immediate and prospective yield under the best available extractive or productive techniques, and also from the point of view of conservation and preservation of cultural values. From this part of the work of the Office there should be available at any time a complete and detailed picture continually kept up to date of the basic supplies on which all productive industry could rely.

(2) *Technical resources.*—This section of the Office would keep under review the techniques of all industrial and agricultural processes : mining, power, heavy industry, building industry, chemical industry, agriculture, food and clothing industry, transport and communications. It would attempt to assess in every case the best existing techniques, with due regard to variation in local conditions, and would endeavour as far as possible to see that the productivity of all industry was brought up to that of the most efficient establishments. This would involve a drastic, but long overdue, revision of patent law, and of publication of industrial secrets. At present, war effort is being hampered by the restrictions placed on the dissemination of technical knowledge, and steps of the kind indicated have already been taken, with excellent results, in certain industries. It is clear that such steps would also be of general benefit in times of peace ; and if the problem is tackled in a sufficiently comprehensive way, these benefits will be found vastly to outweigh the temporary and particular advantages brought about by a policy of restriction and secrecy.

The Office would further concern itself with the improvement of existing techniques, by fostering in every way industrial research, and by using its information service to disseminate rapidly and widely any proved advances in technique. By taking a comprehensive view, it would be in a position to see which branches of industry were relatively the most backward, and were most likely to benefit immediately by improvements in technique ; and it would direct researches particularly in these fields. By its knowledge of the changes in technique which were likely to occur, it would be able to guide industrial development in such a way as to avoid heavy losses due to obsolescence of plant, and to free the development of industry from violent fluctuation.

(3) *Human resources.*—The ultimate resources are human intelligence and constructive ability. The Office would, therefore, concern itself particularly with seeing that the fullest use is made of these qualities, by exercising a general supervision over the selection, education and training of industrial personnel. It would examine what steps were being taken to see that men were able to use their native abilities to best effect. In this it would work in the closest collaboration with educational bodies and with the International Labour Office. It would pay particular attention to scientific personnel engaged in industrial research and development. With the increasing complexity of organisation of modern industrial communities, there is likely to be a serious shortage of such personnel, unless steps are taken now to see that all those of the necessary intelligence and aptitude are enabled to receive proper education and to find places in organised research. The Office would further support the fullest and most rapid scientific information service, aimed at breaking down the isolation of scientific workers from each other and from the technical and general public.

Organisation.—Very much, if not all, of the work proposed for the International Resources Office is at present being carried out by a great variety of bodies, mostly of local or national, but a few of international, character. The Office would not aim at superseding any of these bodies, but rather at co-ordinating their work, and only supplementing it where the general survey shows gaps to exist. It would have these main functions:

(1) Collection and statistical analysis of data on resources.
(2) Dissemination of information on resources and technique.
(3) Co-ordination of existing organisation on an international basis.
(4) Promotion of new industrial and scientific research.
(5) General supervision and co-ordination of standards, specifications and industrial codes.
(6) General promotion of industrial progress by means of congresses, exhibitions, competitions, prizes, etc.

It is clearly essential, if the Office is to attain from the outset an objective and disinterested position, that it must have an independent international constitution, with an assured, though not necessarily large, income which might well be raised by a minute levy on the value of improvements introduced through its activities ; so that, except for the first few years, it would be entirely self-supporting. It would also have to enlist from the outset the goodwill of all existing technical

associations and of the leading technical and scientific experts throughout the world. It would require in the first place a small permanent staff under the control of a group of experts of intelligence, ability and vision. Another necessary part would be an adequately equipped statistical bureau. The great bulk of work would, however, as already indicated, be done by existing organisations, either on their own initiative or on that of the Office. Further, much of the co-ordinating work could be done by the collaboration of voluntary advisory committees, and the creation of *ad hoc* bodies for special problems.

It is realised that the scope of the proposed International Resources Office is ambitious, and that it is certain to meet with opposition from interested or merely conservative quarters. But the situation at the present day is so serious that if we do not take steps to set up such a body, or something very like it, it will be difficult to turn the undoubtedly enormous potential material, technical and human resources at present under the control of the democratic powers into actual war production in time to prevent their defeat. Nor will it be less needed after victory. We can no longer afford to leave the use of world resources to blind economic and national forces. Unless we apply our ordered intelligence to this question, the sequence of crisis and war will continue with ever more disastrous results.

Prof. J. B. S. Haldane, F.R.S.

The Relation of the Soviet Government to Science

My subject is the relation of the Soviet Government to science. In a socialist community science, like most other human activities, is more closely related to the State than elsewhere. While some research goes on in all fields, its main direction is determined by the State Planning Commission, the Academy of Sciences, and the Scientific Research Sector of the People's Commissariat of Heavy Industries. The Academy plans the study and application of science in the fulfilment of socialist reconstruction, and it is worth pointing out that even the Tennessee Valley Authority Scheme of which we have heard this morning would appear as a mere incident in the gigantic programmes of socialist construction of the Five Year Plans. The Academy has far greater resources than our own Royal Society. It has a library of over three million volumes and controls a number of museums and institutes. Its personnel is not unlike that of the Royal Society, but it is somewhat more under State influence, and in turn it has itself more influence on State policy. Its position may perhaps be compared with that of the Bank of England in this country.

The distinction between applied and pure science is held to be unreal. Pure science is merely science whose application to practice has a long time-lag. That was the standpoint of the fathers of British science like Robert Boyle, who valued no knowledge ' but as it hath a tendency to use.' Not all the present Fellows of the Royal Society are as good Marxists as Robert Boyle. In the Soviet Union the same man or woman may work in an industrial laboratory and also in a laboratory devoted to so-called pure research or teaching. The laboratories engaged in pure research are occasionally assigned technical problems. Thus in a biochemical laboratory a grant for expensive apparatus was made conditional on the solution of a problem arising in tanning practice. The absence of secrecy regarding industrial research is, of course, a great aid to the development of a truly scientific outlook in laboratories concerned with such research.

If this were all, however, the system would produce a set of institutes each under the iron heel of a research director transmitting orders from above. Any such tendency is counteracted by the democratic organisation implicit in the word ' Soviet ' which applies in laboratories as elsewhere. The workers in the laboratories, including the technicians, frequently meet to discuss their problems, and the meetings are conducted with a vehemence quite foreign to British academic tradition. Centralisation from above is, on the whole, balanced by initiative from below. I could if there were time give examples where there has been waste as a result of over-direction from above and also of futile research by junior workers in the absence of sufficient direction.

Stalin in his excellent summary of Soviet philosophy stresses the absence of any unbridgeable gaps between different groups of phenomena. In biology in particular this has led to an emphasis on the continuity between species and individuals and between life and death. As an illustration, our technique of blood storage in this country is based on Soviet methods, blood from corpses having been originally used. Segments of the cornea taken from corpses have also been used for the cure of corneal opacity.

We see the influence of Marxism both in the type of problem and its relation to practice. However, dialectical materialism is not an obligatory dogma, and a number of leading Soviet scientists do not accept it. An example of Soviet freedom may be cited from the field of genetics. In 1938 a public discussion was held and a distinguished plant physiologist attacked Mendelism as too mechanistic. According to *The Times* and to certain British biologists, this has led to the ruin of Soviet genetics. I have with me in this room, however, the *Comptes Rendus* of the Moscow Academy of Science over a period of seven weeks of this year, and I find that out of 157 papers, 16, or 10 per cent., deal with genetics or the closely related subject of chromosomes, four of them dealing with the so-called formal genetics of *Drosophila*. This is a far higher output than that of Great Britain before the war.

Science plays a greater part in Soviet education, in particular university education, than it does in this country. It plays a greater part in the education of those whose functions correspond most closely to our civil service. Their education is built up around a core of science as ours is around a core of Latin and Greek. Scientific books are much cheaper in Russia than elsewhere and they form a larger fraction of the total number seen in shop windows. A trivial example will give an idea of the popular interest in science. A few years ago the competition page of a popular Russian workers' magazine had a competition in which names had to be assigned to twelve faces. One of them was the face of our own William Harvey, the discoverer of the circulation of the

blood. I venture to doubt whether it would be as familiar to English readers of competition pages as to those of the Soviet Union.

I regard the relation of the Soviet State to science as beneficial to both parties, but it would not be beneficial in a non-socialist State, nor even in a socialist State unless the influence of the State were balanced by democratic organisation such as that of the Soviets.

Dr. A. Labarthe

THE relations between science and the government of a modern State present a series of problems which ramify widely through all the scientific, industrial, commercial, and political activities of the country. It may even be said that a nation's independence is directly associated with its technical achievements as well as with the quality and scope of its industrial potentialities.

Every industry, if it is to solve the problems of competition, if it is to assure its own development, must not be merely a part, more or less important, of the national machine ; it must have laboratories to maintain at once the hall-mark of its output and the technical researches indispensable to the improvement of the materials with which it deals.

As the problems of industrial manufacture are closely related, more often than is generally supposed, with those of pure science, the ideal system allowing of the optimum development of an industry presupposes the removal of all barriers between the laboratories of scientific research workers, the laboratories of technicians, and the workshops properly called factories. Thus it should be possible to envisage reciprocal relations between these three groups, and the permanent co-operation of the research worker in the laboratory of pure science and the manufacturing technician ; which would allow at the same time of the solution of what are called practical problems and the establishment of new technical formulæ serving as the framework of new industries. One might also envisage the formation of local centres grouping engineers of different techniques and industries, studying the mutual relationship of large industrial groups, and determining the place they should occupy in the national economy.

In France, up to 1936, pure research was concentrated in the laboratories of faculties and schools. Research workers were usually students studying under the direction of the faculty and working on a survey of scientific questions. These laboratories received only part of the very insufficient grants allowed to the Université Française, which were sometimes supplemented to a considerable extent by rich industries with which the scientists, headmasters, or college directors were in touch.

Technical schools, i.e. schools for training industrial engineers, did very little research work, their funds being notoriously insufficient ; industries, on the contrary, often possessed laboratories with highly up-to-date equipment, but the work envisaged for the workers in them was rarely directed to anything but commercial ends, and aimed at quick results. The importance of the laboratories of certain industries depended solely on the nature of the goods manufactured, the margin of profit, and the possibilities of competition. This state of affairs led to a very regrettable cleavage between the activities of the research workers in the faculty laboratories and the engineers controlling manufacture and industrial research.

For example, in June 1940, France had no large special laboratories for experimental work with motor-cars, although in 1934 the production of cars in France was the second largest in the world. American industry, on the other hand, possessed huge official and private laboratories for the study of the mechanical and physical problems of the various parts of a car. Germany, after 1935, made a considerable effort to create enormous laboratories where engineers and scientists worked together. It may be said that if the work undertaken in the Mercédès factory and that of Dr. Porch for the Auto-Union firm brought Germany to the front in the motor-races of Europe, the technical innovations which appeared in type models on the racing tracks brought considerable improvement in current industrial technique. The mechanisation of the German Army has brought as a corollary a general development in research, and it must be recognised that with cars, their suspension, transmission, etc., the ensuing more or less audacious technical improvement testified much more to continuous basic efforts than to the creation of racing teams to raise the national prestige in sporting circles. It was thus in all other industries.

From the moment when an industry, however important, loses contact with the laboratories, which are a sort of generation of brains, giving fresh life to technical processes which tend rapidly to become enclosed by tradition and custom, the industry loses all vital power, all possibility of expansion. It is then that the manufacturer, lest worse befall, buys foreign patents in order to meet competition. A characteristic example of this hiatus has been the French manufacture of Diesel motors. France possessed a considerable proportion of the Diesel lorries of the world, but none of them, except the Renault motor, whose general lines were designed by the Russian engineer, Seiliger, was entirely French in invention or creation, and this tragic paradox applied equally to the manufacturing groups of the *Centrales* and to motor-vessels—submarines, passenger steamers, light cargo vessels. France was not lacking in competent engineers, mechanics and physicists who were capable of studying the problems of injection, combustion, springing and metallurgy on original lines. France lacked laboratories.

Germany, on the contrary, had huge study centres where industrial engineers, constructional engineers, and research engineers, such as Riehm, rubbed shoulders with the young physicists of the Technical High School. Any industry, and in particular that of chemical products, would have served equally as the motor industry for an example of this.

Manufacturers have an answer to these arguments. The building of laboratories necessitates the employment of large sums, and it is difficult to tie up capital in making types whose success is uncertain and whose manufacture is often slow and expensive. We shall see the proposed solution of these problems presently—we will sketch out the relationship between industry and the govern-

ment, but it may be said at once that the maintenance of all national independence, even national security, has become in our time directly connected with the importance of industrial power, with the flexibility of its structure—that is to say, with the development of laboratories, whether for pure research or constituting intermediate stages between pure research and the actual process of manufacture. It must be said, however, that in the realm of aeronautics, on which the security of a nation is wholly dependent, and in which the corresponding industry has not in peace-time a market sufficient to provide funds for the prosecution of long and costly research during the perfecting of new models, the State has intervened in the past. The State is responsible for the maintenance of regular services, the ministerial departments interested build the wind-tunnels and bring into being a body of specialised engineers to ensure the corresponding funds for building prototypes. This example should be general.

In the months before this war, France organised a directorate of scientific research to form a sort of general service of co-ordination of research. Committees and specialist commissions brought together research workers, engineers and industrialists, large problems were divided into groups, laboratory material was inventoried, new centres set up, and it was hoped that in the near future such an organisation would reduce the excessive sequestration in separate compartments of scientific and technical research. A special service was set up for the study and distribution of patents, and a number of credits were in process of arrangement to give a new impulse to science and industry.

But such an organisation cannot be fully efficient without the addition of experimental factories, which might be called ' pilot factories,' for trying out with the fullest industrial verisimilitude new processes and methods. As advance posts of new industries, as intermediate laboratories between the technical school and the factory proper, they would allow of experimentation on a small scale and the formation of bodies of specialists—they would also carry considerable weight in the decisions of industrialists and avoid to a large extent the dangers of routine resulting from mass production.

To-morrow, when in France it will be necessary to take over again the potential industry of our country, laboratory equipment and the genius of inventors will be the essential foundation of the reconstruction of French greatness and her re-establishment in the place in the world she formerly occupied. To give her political independence she must have industrial independence. On that day the first problem to be solved will be that of giving to those with knowledge—that is to say, the scientists, experts, and engineers—the preponderant position which they should occupy in modern life.

Dr. J. Negrin
Science and Statesmanship

RECOVERY, reconstruction and the laying of foundations for a lasting and, if possible, a permanent peace, will depend fundamentally on a successful union between statesmanship and science. No less on this union depends the attainment of the immediate objective of victory in the present conflict, a victory without which all our plans and proclaiming of principles will be in vain. I do not intend here to discuss this statement systematically. Science—pure and applied—and statecraft are not subjects to be confined within the limits of the time at my disposal, which is barely sufficient for a mere indication of the points to be treated.

It is solely my intention to offer, in a succinct and perhaps almost aphoristic form, a few reflections resulting from personal experience—from the somewhat rare experience of a professional scientist who, disliking and shunning political activities, found himself involved in them through the obligations of citizenship, and who in 1936, on the outbreak in his country of a war which is still being fought, was committed by destiny to tasks of government which in one way or another he has continued to perform during the whole of this turbulent period.

I should like to say, first of all, that the spirit informing these considerations does not support either openly or disguisedly a régime of ' technocracy,' less still of ' sophocracy.' Technology and science must provide the essentials for rational government, but they can in no way replace it. Science and government have distinct methods and aims. It is clear that the man of science may possess or acquire the gifts of a leader, but there is no similarity between the formation, discipline or ' style ' of the two. The rôle of the technician and the scientist, as such, is that of a chief collaborator, not a substitute.

Between the statesman and science a dual relation is possible—firstly a passive one, wherein the statesman incorporates learning, assimilates the scientific method and becomes imbued with a scientific spirit ; and secondly an active one, more directly utilitarian, wherein he makes use of the teachings and progress of science for his achievements.

What can the statesman find in science ?

Science can serve him by its capacity for forming a criterion. Scientific criticism and method make it easier to remove the antagonisms of social life and the contradictions in individual conduct and collective behaviour, antagonisms and contradictions produced by that paradoxical human nature which is so full of co-existent antinomies. Science can also serve to correct the professional deformation of the statesman. I do not here refer to those perversions frequently found in the politician, although not specifically or exclusively pertaining to him, such as superficiality and lack of objectivity ; indifference to truth and a taste for fallacious argument ; the ignoring of principles ; an inclination for local or personal favoritism ; a sectarian exploitation of party politics ; and finally a tendency to vanity and a striving after effect, which not infrequently finds its deadliest punishment in adulation, that sweet poison by which so many early hopes of public life have perished. All this is represented by corruption born either of private interest or the desire to ensure, without caring for the means, public favour and the conquest of a power which, when achieved thus, is usually short-lived. Against this science can do little. It is a problem of civic morals and sanity.

I am referring rather to those genuine qualities which are the mark of the statesman and which can easily cause a professional deformation of his personality. Leadership, one of the first conditions of a statesman, implies an instinct for premonition combined with a capacity for cold calculation ; a creative imagination held back by a sane realism ; an enterprising and combative spirit counteracted by a realisation of possibilities ; energy counter-balanced by moderation ; boldness combined with prudence ; ability to form decisions rapidly, but calmly and without undue haste ; firmness and persistence free from obstinacy.

A scientific foundation is no bad method of maintaining the delicate balance required by such opposite qualities and of removing any confusion which might be caused by an incongruous predominance of any one of them.

On the other hand, the great motive power of a statesman is faith in his work. This is needed by the ruler just as much as by the artist and the scholar, for without it no creative work is possible. But pure faith and deep-rooted conviction must not lead the statesman into any dogmatic doctrinairism. Scientific education counteracts agnostic incredulity, but at the same time it is the source of that doubt which inspires action, and it creates that healthy spirit of scepticism which proves the paradox that faith is more intense in those who best know how to doubt.

Science, perhaps more than any other human activity, can infuse in the statesman that prevalent subconsciousness which gives his work an experimental character, his convictions the form of postulates, his ideological doctrine the scope of provisional theory, and his programme the significance of a working hypothesis.

In short, if the statesman can become instilled and impregnated with the scientific spirit, his mission will be ennobled and he can consider himself as an active research worker. In government, as in science, one of the chief incentives must be an ardent desire to discover truth, and even to inquire whether truth exists—that is to say, whether the essence of things and events can be attained by the methods at the disposal of the human intellect.

The foregoing is an exposition of the many fruitful ways in which scientific formation is of use to the statesman.

As far as the question of the services which science itself can offer to the statesman is concerned, this special meeting of the British Association gives the most complete answer.

The vast problems of reorganisation which will be created after the war by a devastated world, with an economic, social and political structure undermined, and in parts razed to the ground, cannot be successfully approached without the help of science. One may be optimistic concerning the possibilities of reconstruction, if routine is placed in chains, and if the leaders of the future do not persist in applying out-of-date solutions to fresh problems. Certain it is that the efforts and wealth of generations have been destroyed, but the countries which have preserved their vitality have always shown unforeseen and amazing powers of speedy recovery after the cruellest of wars. Apart from what is irreplaceable on account of its historical or artistic value, there is nothing that cannot be remade and excelled in a short time, always provided that the help of science is not scorned, and its guidance accepted. In this way it will be possible to avoid a repetition of what for future generations will be the astounding and incomprehensible fact that, for many years after the last war, human labour—the greatest wealth which exists on earth —was recklessly squandered, and millions of men kept in idleness. The totalitarian countries have given proof of wisdom, and have gained an advantage, in utilising—although only in a partial and inhuman form—scientific principles for the creation, provision and distribution of work. If with a more rigorously scientific judgment and progressive spirit, in accordance with the respect which we take pride in conceding to the human personality, the countries affected by the war make an estimate and rational planning of all possible effort, the wounds will soon heal and leave no trace of any scar.

Technology and science have placed at the service of the human intellect tremendous stores of energy which allow it to multiply its efforts infinitely, and to achieve in decades what before the last century would have necessitated a whole historical period. While we are approaching the time when energy will be fabulously abundant and cheap, we may be certain that, even to-day, a rational co-ordination of its production and utilisation throughout the whole world will make it far more easily available and will considerably reduce its cost. In this way a rapid restoration after the war is feasible. Effective effort in the years to come, which will be vitally necessary if our civilisation is not to be destroyed, cannot be made without a planning and rationalisation which must ignore the present state frontiers. For this planning and rationalisation the essential instrument is science. Besides the recovery, reconstruction, and material re-organisation of a world laid waste, the statesman will be confronted with other problems for whose solutions he must look to science : problems of culture, education and general instruction, aids to knowledge, development of research, encouragement of the arts ; problems connected with the physical improvement of the race, with the raising of the standard of living, and the bestowing of a progressive content on collective life, creating new values and morals.

In stormy periods of history, everyday problems are sometimes battered into a different shape, and so made easier of solution. It would seem probable that such widely debated subjects as the scope of State tutelage in science and art, or State control of education and instruction, and of the development of physical culture, lose a large part of their polemical attraction in the light of the new situation created by the war. (*a*) In the first place, collective interest and the instinct for defence demand that every country shall exploit to the full the potential faculties of its citizens, and that in consequence education and learning shall be placed unrestrictedly within the reach of all. (*b*) Secondly, if we are to survive as an independent collectivity, contacts with other countries in order to obtain the highest possible physical, intellectual and professional standard in the citizen are a basic necessity.

It is the task of science to draw up this programme, and of the statesman to carry it out, and to grant that natural desire of the needy to raise and dignify their standard of living, which has been the basis of profound political agitation as far back as historic memory can go. Problems of the future, and of such substance as those which have been touched upon, will constitute the theme of this and, I hope, of future meetings ; but this should not distract us from a more immediate task : the aid which science must give to the statesman in order that we may achieve victory. To give our exclusive attention to plans for the future is like drinking the wine before the grapes are gathered.

Everything in fact depends on the present conflict. In this conflict, it is true, we are fighting for a liberal concept of democracy, for the independence of the peoples, for the rights of the individual, for a progressive conception of the world. But that alone does not represent the essence of the present struggle. Beneath all this there is something biological, primitive and animal, with which we can only find an analogy by going back in imagination to prehistoric times, when races and species perhaps disappeared altogether in conflicts of extermination.

A people who—sad truth though it is—knew better than any other how to take advantage of science in their endeavour to achieve hegemony, have been seized with the delirium of Lucifer, and as a god-like nation are trying to subjugate the rest of the world. Their resources are terrifyingly great, their preparation solid, their foresight meticulous, and the risk which they represent to all of us is greater than has ever been known in history. In the tremendous life-and-death struggle which is now being waged, a struggle wherein no effort can be too great, and wherein no one has the right to consider himself as standing apart from good and evil, science must not only assist—as she does already—by improving the methods for destroying the enemy and for protecting us against his attacks, but also, in the spiritual sphere, by serving as a lantern to show us our path and a leaven to lighten the task of the statesman.

The historical cycle begun in the second half of the 18th century and characterised by the clarification of democratic principles and the struggle for their application, is showing, in my opinion, symptoms of decay and is about to give place to a new epoch. There have been abundant conflagrations during this period, and the present moment is perhaps its crisis. From an historico-scientific examination, the statesman may gain concentrated experience which will allow him to sketch in outline the generic features of the present age. This retrospective analysis will make it possible for him not only to distinguish by contrast obscure contemporary phenomena, but will also give him an historical perspective which will show what is homogeneous in our epoch and will reveal the *leitmotif* at present hidden by a veil of confused happenings. From this standpoint it can be seen that we are witnessing the gestation of a new world, and if the nations try to prevent its advent by supporting the old and outworn, they will jeopardise not victory alone but their very existence. This has been only too well understood by those countries which in the world to-day represent retrogression and barbarism, and have therefore nailed to their mast of hysterical deception the colours of revolution.

The advance of humanity is a discontinuous process, and even its evolution is achieved in sudden leaps. Restriction in its development, if it could be brought about, produces stagnation, involution and death. Just as in living nature, human society accumulates impulses for renewal, and suddenly a revolutionary phenomenon appears as though by an abrupt mutation. In my opinion there is no doubt that we are living in a period of tremendous mutations. And here is a new field in which science can serve as mentor to the statesman and can help him to remove the obstacles in the way of rejuvenation and progress, such as a decrepit archaism, and false traditions which kill spontaneity and lead inevitably to a régime of snobocracy. There would be no culture or civilisation without traditions. These prevent us from breaking away from the past and losing the idea of continuity. Indeed the symbol of human progress is a quintessential system of traditions. In war the ideals which inspire us are a stylised synthesis of our European, Christian and human traditions, the finest creation of the spirit and substance of our civilisation.

But how many examples are there in the past of peoples who have fallen beneath the load of their own obsolete traditions ! Every tradition which is not historically dynamic contains the germ of death, but traditions generally necessitate a periodic revitalisation in accordance with the spirit of the time. Science provides the touchstone to reveal the senescence of traditions and to point out those which need renewal and those which should be removed. Science can give new life to inanimate traditions. As also occurs in questions of belief, everyone in matters of science proclaims the incontrovertibility of his doctrines. And although we all maintain our convictions, I do not wish to fall into the error of proselytising my audience. But the politician will find in science a sieve by which he can distinguish, classify and purify the aspirations of the masses who are fighting, and an apparatus for elaborating and formulating feasible solutions.

Jurists, sociologists, economists and historians, principally, with the help of the other sciences, will have to prepare the varied formulæ, formulæ which will not force a hasty improvisation, at the end of the war, of the solution of the fundamental problem of establishing a supernational and super-State organism, in sympathy with our democratic designs, but with sufficient authority and strength to enchain that part of national sovereignty which it will be necessary to sacrifice on the altars of a durable peace.

In the hearts of our fighters there lives a faith in democratic principles, which are the kernel of our civilisation, and which are manifested by a complete individual liberty as far as thought is concerned, and only restricted in action as the legitimate interests of others are affected ; by tolerance—a corollary of liberty ; by the idea that the people are the source of public power, and that their will, expressed directly or through

delegates, is the decisive arbiter of their own administration and government. For those who to-day are fighting for a democratic State, this represents the defence of collective interests and the guarantee of what we consider the rights of the individual.

Science can render a valuable service to statesmanship by paying attention to the following points :—

Selection of leaders in every field of national activity.
Regard for the education of the masses.
Active participation in public life.

It is the patriotic and human duty of the scientist to bend himself to these tasks, tasks to which the statesman should summon him. His special conditions are of exceptional value in the present circumstances, particularly the wide feeling of tolerance which is perhaps more common among scholars than in any other class of society ; the zeal for truth, which should be the common denominator of the scientist ; and that wide international and universalist comprehension which—as far as it is possible in human beings—is free from exclusivist prejudices of race and creed.

In order to create a new and better world it is not enough for the statesman to rationalise government and to plan on a world scale. It will be necessary to promote and infuse new moral values, to which the scientist will give form and content, in a supernational and humanist sense.

In the last resort the goal of science and statesmanship is similar : they both in their proper spheres pursue truth, a quality which in the realm of human relations finds its highest expression in fairness. liberty and justice. Twenty-four centuries ago Aristotle said in his *Ethics* that the supreme end of politics was human good. In the same sense as that of the Stagirite philosopher we may say that the highest aim of man is goodness.

Prof. Alex. Photiades

The Actual Point of View of Greek Scientists on the Contribution of Science to an International Policy

I SHALL not deal with the contribution of ancient Greek civilisation to the progress of science and technology, but I shall at once convey to you the opinion of the scientists of modern Greece. The potentialities of science and technology have been considered by the modern Greeks from the standpoint rather of a static equilibrium, and their dynamic form was not scientifically examined. We feel now, however, under the impact of war in its various destructive phases, the need for considering dynamic results.

If one of the basic needs is free association, we must examine the possibilities for the constitution of a scientific national policy dealing with technical activities. We must seek a larger federation either by union of national bodies or by other means, so that, though not by authoritarian power, an international technical league or federation may derive its power not from an imposed exterior authority but from its own scientific and technical work and its evident value from the point of view of the public good. This free league or federation will not only have to act as a mediator but to have some responsibility for international control of materials. In a more general way it will survey the whole of the technical potentialities of each country for the fulfilment of some international technological order, and the interdependence of such an order in the economic sphere in the new age must not be forgotten.

Dr. P. P. Ewald

Pure Science and Politics

IN the coming reconstruction of the world applied science will obviously be of immense help. The part pure or theoretical science can play in politics follows from an analysis of the scientific method as contrasted with the political method.

The object of pure science is to give an accurate and condensed description of the processes found in nature. Human relations, including economics, can be studied as forming part of a biological process ; in the psychology of masses, in the statistics of economics and of populations, and in the application of mathematics to economical and biological problems we may see attempts to master socio-biological problems by scientific methods.

Scientific investigation must be unbiased and unrestricted. The main bias for a scientist is introduced by the starting-points he has to accept, and by his eagerness to obtain results. The latter has often led to wishful thinking and to wishful interpretation of observations, and this danger is particularly imminent when studying human relations. Therefore the scientist must endeavour to eliminate from his work human influence, or, if this is not possible, he has to point out exactly where this influence becomes decisive.

Politics—applying the word in the widest sense —is the art of establishing or changing relations between human groups according to a plan. Politics are largely dominated by will, namely, whenever it comes to choosing one out of several possible courses. Far from being pointed out, this human influence in politics has often to be concealed in order not to frustrate the desired effect. The method of politics is thus opposed to that of science.

The two activities, however, are dependent on one another. Politics depend on science for providing the data and the forecast on which to base the political decision. Science depends on politics because it can thrive only in a well-ordered society which is prepared to assist it materially and at the same time to grant it a development unimpeded by economic, political or other human interests.

An extension of scientific methods for collecting and discussing socio-biological data will tend to make politics more rational by reducing guesswork in estimating the consequences of proposed decisions. But even if a clear forecast became possible by detailed application of scientific methods, the political decision as an act of will remains to be taken. Since there are conflicts between the interests of the parties affected, or between short and long term interests, a decision implies an ethical background, without which it would be undeliberate and amoral. For the relations between individuals this background is

fairly uniformly established by the acceptance of civil law, of tradition and of charity ; but for the relations of nations only a very incomplete and heterogeneous background is given by political and economic ideology, by religion or *Weltanschauung*, and by ill-defined racial feelings.

If a new world is to be planned, this can be a success only in so far as the nations are agreed upon the ethical background on which political decisions are to be taken. Theoretical science can help in two respects in forming a common background : first by finding what part of the changes in human relations is due to general laws and where exactly the political decision comes in ; and secondly by setting, in her own research and teaching, the example of integrity, honesty and international unity—an ideal which should appeal to those who have to adapt their ethical background to co-operation in matters political.

SCIENCE AND HUMAN NEEDS

FRIDAY, SEPTEMBER 26 : AFTERNOON SESSION

CHAIRMAN : H.E. THE AMERICAN AMBASSADOR, MR. J. G. WINANT

The Chairman

IN a world tried by ordeal of battle, and with a large area, in which both pure science and applied science have been developing over the centuries, now in subjection, the significance of this international conference as it relates to a continuing civilisation is obvious to everybody.

In my judgment the first service that may be rendered by science to human needs at the moment is the integration of scientific method and applied science in support of the allied armed forces that are organising to destroy Nazi power, which has with relentless efficiency and cruelty degraded the dignity of the individual and attempted to abolish the rights of man. For Nazism has stolen and run amok with the great inventions of free and enquiring minds and is using them not to liberate but to enslave the human spirit.

And yet men of progressive minds cannot meet in these troubled times without daring to look beyond war to victory and to peace, and to consider the re-establishment of science in the service of a constructive civilisation and with a greater consciousness of the need of international science as the servant of mankind.

We must recognise already that when we leave the battlefields of this war we will move into a wounded world of immediate needs and crowded wants in which the healing hands of science and the constructive powers of the mechanical arts are an essential part of any brave new world.

In our great effort to re-establish political rights, which is necessary if we are to have scientific progress and the free mind, let us never forget the obligation of science to satisfy the primary needs of man so that the essentials of life are recognised equally as a part of the rights of man. This is necessary if we are to have security. We must abolish both hunger and the sword as means of forcing labour. In that way only can we give meaning to that equality which proclaimed for all men everywhere the right of ' life, liberty and the pursuit of happiness.'

Prof. Emil Abel

SCIENCE and Human Needs is the theme of this afternoon's session. Especially for those scientists who, like myself, had to leave their country and were happy enough to find hospitality in the United Kingdom or in any other part of the British Empire, this title seems to me to indicate the very best way in which we could show our gratitude to our hosts : to follow the lead of our British colleagues in trying to put our knowledge also into the service of human needs.

Others, colleagues as well as pupils, have found their new field of activity in the other great democracy across the Atlantic and are fortunate indeed to co-operate there with their fellow-scientists. Again, all of us breathe the free air of free countries. What a tremendous change of air ! And who indeed should be more competent than the chemist to find proof for it ? We have always heard that the composition of air is practically the same all over the globe. But certainly the chemist must have made a mistake somewhere, the analysis should be repeated as soon as possible, for how can the oppressing air over Vienna or Prague be the same as the refreshing and exhilarating air over London or New York ?

In former days the question has been raised, whether there are ways to bridge the wide gulf between the laboratories of the physicist or chemist, and the places where their research work is put into practice. To-day we are all—especially in these times of emergency—witnesses of the immense traffic passing over those bridges, which British scientists, chemists and physicists, doctors and engineers, botanists and zoologists have built, leading from their creative minds and their workshops—however different they may look in

each case—to the places where their thoughts are being transformed into production and output.

'Nothing is more practical than theory.' Ludwig Boltzmann, the great Austrian physicist, told me so himself many years ago, and how right he was with this seeming paradox has since been proved everywhere. From the British scientist Maxwell, one of the greatest physicists and thinkers of all time, a clear path leads to the world-wide transmitting and broadcasting system of to-day. The physician as well as the patient will have to thank—perhaps in the near future—the vision of Lord Rutherford, for the possibility of healing with artificial radio-activity by having given the world the very insight into the structure of the atom.

Such examples are thousandfold. Wartime has a tendency to accelerate such developments. That possibilities are being given also to Austrian scientists to contribute their modest share within the framework of the all-embracing science is not only an honour to every one of us but also an obligation. May the British Association, for whose invitation I have to express my thanks, and furthermore His Majesty's Government, be assured of this our attitude.

Sir John Orr, D.S.O., F.R.S.

THE planning of applied science to provide for future human needs in food should prove easy, because we know what the human needs for food are. In the last few years a number of different and quite independent bodies have set themselves to draw up a standard of requirements for health. The British Medical Association drew up what is known as the diet at minimum cost. The Home and Economic Section of the Agricultural Department of America drew up a diet on standards of moderate cost. Then the International Committee appointed by the League of Nations, a Committee which had on it scientists from all the great nations, with the exception of Germany and Italy, drew up a dietary standard irrespective of cost ; a dietary standard which would assure the fullest possible health and vigour to all, as far as it can be done by food. Then, more recently, the American National Nutrition Council, which applied its mind to the same problem, have drawn up the lowest standard. When these standards are expressed in terms of foodstuffs, we find that among the well-to-do families, those whose choice of food is not limited by purchasing power, the average kind of diet does conform with the standards : and we know that those standards are right, because in recent years there has been a number of children whose mothers have been, not fed like experimental animals, but given a free choice of food and have taken food on those standards. Mothers have been fed on diets which conform to the standards before their children were born ; and we find those children grow more rapidly and their physique and increase in mentality are better. These children come above the average even of the children of the well-to-do classes. We can take it that these standards drawn up by independent bodies, standards in accordance with human experience, are standards which have been tried out not only on animals but on human beings, and that they were approximately correct.

If you use those standards as a yardstick to measure the extent to which diets conform with them, you find that a very large proportion of mankind do not reach anything like that standard. About five or six years ago an attempt was made to estimate diets in the United Kingdom, and it was found, to the astonishment of the people who were making the estimate, that, roughly speaking, the diet of about one-half of the population did not reach that standard. Those estimates were received with a good deal of incredulity. But the United States of America has done far wider and broader investigation than any other country in the world, and there something like the same conclusion has been reached. I wish to quote from an official document which was issued in March of the present year by Miss Perkins, which says : ' It has been estimated that 45 millions of our people are living below the food diet danger line. Many of these are children who will not grow up to be healthy citizens unless the diet problem is tackled now.' I could quote even higher authority in Mr. Secretary Wallace, now Vice-President of that great nation, and formerly Minister for Agriculture, who wrote in a foreword to the official yearbook from the Department of Agriculture that ' about 50 per cent. of the people in the United States do not get enough in the way of dairy products, butter, fruit and vegetables, to enable them to enjoy full health and vigour ; and a large proportion of them do not enjoy it because they cannot afford it.' Those figures are from the two wealthiest nations in the world ; and we can take it that the average of the other nations is below that.

Let us compare health with diet. We find in all countries that as the family income falls (which is very often on account of an increase in the size of the family) the diet becomes worse, and at the lowest level, amongst the poorest 10 per cent., the diet is deficient of the main food constituents in every way. The children reared on that diet, and the people who exist on it, are not starving. They are living—at least they live for a time—but they are not living to the full. You find as you go down the scale, as the diet becomes worse, that health becomes worse. Near the bottom of the scale is where you find the greater liability to various diseases arising from food deficiency. That is where you find the high mortality, which is one of the surest indications of the physical standard of the nation. In our own country at that low level the mortality level is round about 100 per thousand, as compared with 30 per thousand among the well-to-do. Among females there are some figures for recent years which show that where mothers have been purposely put on a completely adequate diet this mortality rate is down below 10. The incidence of tuberculosis is lower down the scale among the poor part of the population : but it is a fact that, at any rate among the well-to-do, you find that stature is better as compared with men and women at the lower level on the poorer diet to the extent of four inches. They are suffering from stunted growth due to deficient diet. We find that mental deficiency is also prevalent and customary amongst

them. It would be no great exaggeration to say that a greatly deficient diet is correlated with disease, with physical disability and with premature death. But we must not say that diet is the sole cause of these things, because there are other factors associated with a faulty diet. Bad housing, overcrowding and, not the least important, psychological factors such as the frustration of unemployment and the carking worries of want, profoundly affect health. But we do know that diet is one of the important factors ; because when we take children, without changing the other environmental factors, and improve their diet, they begin to grow at the same rate as the children of the well-to-do ; we find that their health is better.

The few experiments which have been carried out show that their education improves very rapidly, even if intelligence is an inherited characteristic, because on these poorer diets there is an early onset of fatigue, and there is lack of power of concentration in the child, who cannot take advantage of the education which it is afforded. Some experiments that have been carried out in the Army recently, a year or so before the war, show that similar improvements can be brought about even in adolescence. The best experiment of all, and the most convincing, is what has happened in this country in the last twenty-five years. As you know, in the last twenty-five or thirty years there has been an enormous improvement in the health and physique of the people of this country. The gravest deficiency disease of infancy is rickets ; and it has almost completely disappeared. Infant mortality has been cut in half ; the tuberculosis rate has been cut in half. The children of to-day leaving school are two or three inches taller than their parents were. At some schools where they had not got new forms, they had to take the blocks up, because the legs of the children are so much longer than the legs of the children of twenty-five years ago.

This outstanding change that occurred at the same time is not due to any great advance in medical science in the treatment of disease. The big change which has taken place is in the feeding of the people of this country. In that same period the average of consumption of protective foods for the whole population—that is, the things which people find necessary to life—has been increased by as much as 50 per cent. You have a correlation between the improvement of diet and the improvement of health. You would assume, at least as a working hypothesis, as a hypothesis which we know will not do any harm, that if the State could bring about a food policy which would provide a dietary up to these standards, that would mean the elimination of a great deal of disease, a great improvement in physique, and a much higher level of physiological and psychological well-being.

But a food policy based on human needs has much wider reactions. One of our objects in planning is to get rid of poverty. The working classes spend 50 per cent. of their total income on food. If we had a policy, either by raising wages, by subsidising food or by children's allowances—the financial, economic and political experts can say which is the most convenient—if we had a policy which raised the purchasing power of the poor to a diet adequate for health, you would have a very big rise in standards of living which would eliminate all the worst features of poverty. If every parent were sure that, whether in employment or out of employment, whether in health or in sickness, or whether he lived or died, his children (while we no doubt would lose some luxuries) would always have sufficient food to enable them to have the opportunity of attaining a full inheritance of health and well-being, you would remove one of the worst causes of war and fears of want. I believe that there is no measure that would do more for the promotion of human welfare than a food policy which would bring within the reach of every individual a diet completely adequate for health.

We have to recognise that a policy on those lines would bring about profound changes in agriculture. We would need a very great increase in protective foods—milk, eggs, fruit and vegetables. The United States—which is far ahead of us in these estimates—has estimated how much more would need to be produced in that country, not for export but to bring its own diet up to the level of the minimum for health. These estimates show need for 15 per cent. more butter, 20 per cent. more milk, 35 per cent. more eggs, 70 per cent. more fruit, and 100 per cent. more vegetables. In this country the increases would be probably approximately the same, except that instead of 20 per cent. increase in milk we would need 100 per cent. increase in milk to bring our milk consumption up to the level of what would be required.

If we are going to do that, the pre-war policy of dealing with gluts has to be changed. There is a great world shortage of food. There is no likelihood of a world glut of things in our day or in our children's day : and the stupid political policy which, not through evil thoughts but through ignorance on the part of economists, financiers, and politicians, was restricting the production of food and the distribution of food in times of so-called glut, would need to be replaced by measures in which science would be applied with all its power to improve the production of food. Trade will be facilitated for the adjustment of the distribution of food in accordance with the needs of the people.

If we are going to attain that in the world after the war, we will need to take an estimate of the food which each country can produce ; and the kind of food which will be grown and which each country can most easily cultivate. If two acres of land can produce more sugar in the West Indies than two acres of land can produce in this country, the West Indies will need to give itself up to the production of sugar, because we will need our land to produce milk and other things as profitably as other countries can do. In other words, there will need to be an interchange of food between nations. We will need not only to produce more food in this country, but we will need to import more food. The interchange of food between nations will lead to the interchange of other commodities ; and so you will have to lay a basis for expanding trade.

There is another very important thing from the economic point of view, and that is that the

amount of food which we need to produce from any group of countries in the whole world can be fairly accurately estimated. If we produce somewhere more than is needed, the people cannot eat it. If we produce less, we will know that there is a shortage there. So that you can arrange your food policy on a stable basis. If there is a trade boom or a trade slump, people will need the same kind of food, and they must produce the food required for human needs. As the consumption of food represents a great proportion of the annual income of almost every country of the world, if you introduce that kind of policy you introduce a stabilising factor in the whole trade of the world.

I have tried to say that you can make the food policy a spearhead for human welfare and for the extension of trade, causing economic stability. Some people may think that these ideas are rather utopian and that they cannot be carried out. But I tell you we have begun now to carry them out. The United States of America, with its food planning and taking the surplus food and placing it where it is needed most, is providing diets which are more adequate for needy families and improving the national health. At the same time it is broadening the market of food production and helping the consumers of our country by increasing the exchange of food commodities and by helping business. A movement has already taken place in those terms in the United States.

In this country the war has forced us to adopt a food policy based on an official standard of human needs. We can no longer produce what the farmer thinks will give him the biggest profit. We have to produce the food required to feed the nation, and other countries will proceed on the same basis. We have a rationing system ; and I venture to think before the war finishes there will be an extension of that rationing system to bring food production more in line with our needs. We shall soon have food rationing to provide food which is specially needed for those engaged in heavy employment, such as miners and dock labourers. There will be additional rationing to make up an appropriate system to suit the particular industry in which men are working ; and so you will have to adapt rationing so that additional foods will be given to certain types of industry. It will be a system whereby you will see that the right men get the right meals. In doing that the United Kingdom are doing what will be done eventually on an international scale. The United States, that great, generous nation, is sending us the foods that we are asking for ; and in some cases is restricting its own consumption, not with the idea of improving its trade or maintaining financial adjustment, but because our nation needs this food, and it has the food to give.

At the end of the war Europe will be threatened with the greatest catastrophe which has happened to the human race. Plans are being made to provide food to save starving Europe. I make the suggestion that we should do something more than that. The time is short. When the war comes to an end, there will be no time to improvise things and evolve policy. I would like to suggest here and now, to-day, this year, that the Government, and the governments of our allies, should appoint an International Committee representing America, the British Commonwealth of Nations, Russia, and representatives of the free nations which are with us, to work out a world-wide food policy based on human needs. We know that there will be great difficulties in the way ; and there will need to be some change in the economic system. It will be a very bold financial system which will provide facilities for expansion, which would be continually increasing. But those difficulties can be got over. It will be pointed out by some that you are up against very stiff vested interests. But these people who control the food trades are there because we allow the vested interests to come in, while the financiers and the financial interests have to handle the policy which has to be carried through. I think sometimes there are some things which are quite wrongly approached. These people have not been asked yet to do anything different. They are only doing what the Government asks them to do. Supposing the Government said that ' an international group of governments is going to adopt this policy and we need your technical knowledge to help to handle the food and to adjust matters so that various foods can be earmarked for various requirements, and we invite you to put your financial skill at the service of humanity,' I believe that a great many of these people would be glad and happy to co-operate with the other branches of science and industry. They would get the vision of this idea which a number of us have ; and they would be willing to come in and plan and help in this new food policy that many of us would like to see brought about.

I have tried to say that a food policy based on human needs would lead to great improvement in human welfare, to a great expansion in agriculture, to an increase in trade and to the producing of economic stability. It could be used as a spearhead for that movement. If we brought about that rise in human welfare, expansion of agriculture, and economic prosperity, we would have those conditions which can only be brought about by the co-operation of nations—we would have those conditions which are themselves security for a permanent peace.

Sir Harold Hartley, F.R.S.

World Heat and Power Requirements and their Social Implications

ANY discussion of the relation between science and human needs must include the world requirements of heat and power, since the utilisation of the free energy of coal was the fundamental factor in the Industrial Revolution which changed social conditions so profoundly. It is no exaggeration to say that without the successive developments that have made available heat and power most of the scientific discoveries of the last 200 years could not have made an effective contribution to the progress of civilisation. The milestones were James Watt's improvement of the steam engine in 1769, Fulton's steamship in 1807, the birth of the gas industry and the distribution of energy in the same year, Stephenson's ' Rocket ' in 1829, Faraday's discovery of electro-magnetic induction in 1831 which culminated in the first power station fifty years later, Otto's internal combustion engine in

1876, the Swan Edison lamp in 1879, Parsons' invention of the steam turbine in 1884, and the Wrights' first flight in 1903.

The main results of this progressive utilisation of energy were :

(1) Power-driven machines, with a continuous increase in the productivity of labour and material resources, first in industry and later in agriculture.

(2) Means of rapid transport by land, sea and air, facilitating the development of new countries, making available the world resources of raw materials and food, and providing new markets for industry.

(3) The development of metallurgical and chemical industries, producing secondary raw materials for industry and fertilisers for agriculture.

(4) The high voltage distribution of electricity, making possible the dispersal of industry and thus avoiding the overcrowding of urban areas.

Following on these results of the applications of energy in industry and agriculture has come another revolution no less far reaching, the Domestic Revolution—the scientific application of heat and power in the home, which in the fields of lighting, heating, cooking, refrigeration, air conditioning and many other ways has done so much in this century to save labour, give greater comfort, and, above all, raise the standard of health of many millions. It may be regarded as the repayment by the technician of a deferred debt long overdue for some of the social consequences of the mechanisation of industry in the nineteenth century.

It is not irrelevant in this Institution to read an extract from a letter from its principal founder, Count Rumford, to Sir Joseph Banks, dated 22nd January, 1800.

'I am expecting the arrival of Webster every moment. I am glad you have sent him here, for the drawings he will make of the works that have been executed in the Romsey Public Kitchen will save me much trouble (for I must have made them)—and his seeing the kitchen here will enable him to be of great use to me in directing the works in Albemarle Street.

'I shall bring with me to Town a very clever Bricklayer of this neighbourhood, who is desirous of completing his education under my auspices at the Royal Institution.

'Our Roaster here has been publickly tried and the meat roasted in it was unanimously preferred to meat roasted in the common.

'I cannot finish this letter without communicating to you a very interesting, and, if I am not mistaken, a most important discovery I made three days ago. The process of cooking meat called boiling may be performed with a degree of heat considerably below that of boiling water—and the meat so cooked is uncommonly savory, and high flavoured. A piece of the toughest neck beef was made very tender in about three hours. I do not believe it could have been made tender if the water had boiled. I shall not fail to push these enquiries to the utmost.

'Lord and Lady Palmerston and Sir Charles desire to be remembered.

'I am, my dear Sir, with unalterable attachment, and perfect esteem,

Yours most faithfully,

RUMFORD.'

Rumford was the pioneer of the Domestic Revolution, and his letter is a timely reminder that there is still a great need for research in the science of cooking.

Since the utilisation of energy has played such a vital part in increasing productivity and the standard of living in the past, it should be an equally important factor in the period of reconstruction for which we now have to plan. The achievements of power are too often dismissed with picturesque phrases without quantitative consideration, and this paper is a plea for a detailed consideration on a quantitative basis of the energy problems and possibilities involved in any schemes of reconstruction—world energy resources, their utilisation and conservation. Much material is already available for such studies in publications of the League of Nations and various Governments, in the investigations of bodies such as the National Industrial Conference Board, and particularly in the Statistical Yearbooks of the World Power Conference and in the Transactions of its Meetings, which contain reports on most aspects of energy problems submitted by the national committees of over forty countries. Much remains to be done to make these statistics more complete and informative, but they are an indispensable basis for planning the future.

From 1820 to 1900 the world annual consumption of coal showed a steady logarithmic increase from 20 to 778 million tons. In 1936 the world requirements of energy, apart from that supplied by human and animal labour, were met by burning approximately 1,400 million tons of coal, 240 million tons of oil, 400 million tons of wood, 50 million tons of natural gas, and generating 130,000 million units of hydro-electricity. The proportionate contributions of useful energy from each of these sources, assuming an average efficiency of 50 per cent. for fuel and 90 per cent. for electricity, were coal 63 per cent., oil 18 per cent., wood 12 per cent., natural gas 5 per cent., and water power 2 per cent. If all the potential water resources of the world had been harnessed, and many of them lie in remote regions, their maximum contribution has been estimated at from 15 to 30 per cent. of the world's requirements, so it is clear that the burning of fuel must continue to supply the greater part of the world's energy consumption until other means have been discovered of utilising the sun's radiation. About 60 per cent. of the world coal production is ultimately used in the form of heat and 40 per cent. in the form of power. At the present rates of consumption the world coal reserves including lignite would be sufficient on an average for 4,000 years, those of Great Britain for 750 years and of the United States of America for 6,000 years. No estimate has been made of the world's oil reserves although they are almost certainly much less extensive than coal.

This is no time for complacency because of the improved standards in the industrialised countries, as even there the inequalities are great and we must remember that the steady improvement of conditions in the nineteenth century took place under the stimulus of the rapid development of virgin countries, suitable for European immigrants, and of rapidly increasing population—a phase which ended by 1900. It is pertinent

to ask how far the lack of adjustment to the 'closing of the frontier' is responsible for the economic vicissitudes of the twentieth century. The majority of the inhabitants of the world are still living on a miserably poor level, far below what we have come to regard as the minimum of physiological requirements.

What can science do through the utilisation of energy to help to solve the immediate problem of reconstruction, and what are the long range problems in this field? The immediate problem is to raise the world's productivity, particularly in the backward countries, and to secure the equitable distribution of the products in relation to the needs of each country, thereby eliminating the waste of energy involved in the search for self-sufficiency within arbitrary geographical boundaries. The initial stimulus must come from the technical resources of the developed countries, and may entail a quick and lavish expenditure of energy and resources. But in replanning conservation must be the guide, for in spite of the large world resources of fuel, these will become increasingly more inaccessible. They are of widely different types and we must avoid exhausting prematurely those of special character such as caking coal. The Soviet Government has already taken effective steps to safeguard this key fuel.

The energy problems in the developed countries are relatively clear and simple, and technological progress will continue to solve them. The one consolation for air-raid damage is the opportunity it offers for planned development. Maximum economies must be obtained in the winning and distribution of fuel, and in its utilisation, with the constant objective of making energy cheaper and more generally available. Let me illustrate one way in which planning would help. The generation of electricity by means of condensing turbines must always involve considerable heat losses. The remedy for this is regional planning with a view to securing as far as possible the joint use of heat and power, the heating being done by steam extracted from the turbine after partial expansion, thus saving the losses due to condensation. The carbonisation of raw coal and the use of electricity in some co-ordinated scheme, designed to secure the maximum advantages from both, will help to solve the problem of smokeless cities, and will provide the cheap energy needed in the homes of the future.

One of the major problems of developed countries is the inequality of conditions in the town and country. Agriculture still retains much of its primitive character. Wider application of energy on the farm, and in conditioned transport and storage, would increase productivity, ease the conditions of life, and accelerate the processing of farm products, a development which is now in its infancy. But I have in mind those four great regional laboratories in the United States planned by Mr. Henry Wallace when Secretary for Agriculture to investigate the processing of farm products in order to discover new uses for them. Experience in Canada, especially in Ontario, and in the United States under the stimulus of R.E.A. and T.V.A., has shown how much the tractor, the motor vehicle and electric power can contribute to higher standards on the farm. In my Mather Lecture on 'Agriculture as a Source of Raw Materials for Industry' I showed that at present about 88 per cent. of the world's agricultural production (on a value basis) is used as food, 8 per cent. as textiles and 4 per cent. in other industries, the last two together representing roughly one-third of the raw materials of industry. There is a growing tendency to look to agriculture for a larger proportion of these raw materials, but this must depend largely on processing and on the factory becoming an adjunct of the farm.

Of the 2,000 million inhabitants of the world over half live in the less developed countries and depend mainly on agriculture. Their energy problems are much more urgent and more difficult. How can their standards be raised, and can they, with the aid of scientific development, provide the new outlets for world industry as the virgin countries did in the nineteenth century? The answer has been sketched by Professor Noel Hall in his 'Memorandum to the League of Nations on Measures of a National and International Character for Raising the Standard of Living.' In the most backward countries, where many millions are existing on subsistence agriculture isolated from any means of helping themselves, the first need is cheap means of transport, adapted to the needs and energy resources of the particular region. This would provide a means for the exchange of products and thus expand and diversify existence in primitive communities. The problem is really that of changing their mode of life and opening up for them new possibilities. With the stimulus of communication and the help of markets, demands will come gradually for simple implements and machines, fertilisers and the simpler amenities of life.

In the less primitive countries the problem becomes relatively easier but the elements remain the same—improved transport and communications, better means of storage and marketing, power driven machinery, the processing of products, and every means of raising productivity without impairing the fertility of the land. In all these measures energy has a primary part to play, and by helping on the one hand to increase the output of agriculture and on the other to create fresh demands for industry, it can improve the standard of living in both, thereby easing the economic relations between agricultural and industrial regions.

These are the immediate problems which require rapid and intensive attack when reconstruction is possible. With the scientific knowledge we now possess of standards of consumption it should be possible to plan with much greater certainty than in the past. Meanwhile we can leave to fundamental research the longer range problems, confident that it will yield continuing improvements in the methods of utilising fuel, in the distribution and storage of electricity, in the uses of power, and in the production of substitutes for mineral oil from coal or vegetable products against a possible shortage. The ultimate goal is the utilisation of the sun's radiation currently by some photochemical or photoelectric device or engine to take the place of the solar energy stored in coal and oil. These are

the long range problems to be solved in the days to come when once more it can be said that science knows no frontiers, but her immediate task is to ensure that in the replanning of the world full use is made of the basic knowledge that she alone can provide, particularly in the fields of nutrition and energy with all that they imply for the well-being of mankind.

Rt. Hon. Herbert Morrison, P.C., M.P.[1]

THE direct and immediate effect of science on society in the last century, apart from the field of medicine, sprang mainly from its improvement of methods of production. Men learned to grow two—sometimes two hundred !—blades of grass where one grew before : to mechanise manufacture and speed it up sevenfold : to bring about an international division of labour through a revolution in transport which brought the world into closer physical unity. Unfortunately this scientific and industrial advance has not been sufficiently organised for social ends, for the common good.

To-day, while the effect of scientific progress on production still continues, the impact on society of the scientists and their methods comes more sharply still from another direction. Within the last generation science has given us a new body of exact knowledge about human and social needs. We now know, as men in earlier years did not know, something about basic requirements in food, housing and town planning, clothing, rest and education. We know more in some of these fields than others, and we have not got quite beyond the stage of controversy in any of them. But we are beginning to feel firmer ground under our feet than ever before : and we are beginning to appreciate that the area of firm ground will increase steadily, as scientific method is extended in the sphere of physics, chemistry, biology, psychology and the social sciences.

What is the character of this new scientific knowledge about human needs? It is at its most advanced, most exact and least controversial in the field of diet. Not all scientists are agreed about correct standards. That would be asking too much of human nature. But within fairly narrow limits they do claim to know what diet is necessary for existence and—a different matter—for good health. Moreover, what the biologists have discovered in the laboratory has been grimly documented by the social scientists. They have told us that in Britain, one of the wealthiest communities in the world, nearly half the population a few years before the war had a diet below the minimum needed for health. We know also that startling results on the health of adults and the growth and health of children have followed on simple improvements in diet made under controlled conditions. Finally the great experiment made possible by the war itself has demonstrated triumphantly that a people living on a diet more restricted in bulk and variety, living too in conditions of great strain and dislocation, can actually be healthier than before, when steps are taken to ensure that the food they do get contains the right proportions of those ingredients needed for healthy living. The scientists would be throwing up their hats over this resounding demonstration of the validity of their theories—if scientists did that sort of thing. Perhaps they will say that they leave it to the politicians !

But the improvement in national health during the war must not blind us to the fact that we are, partly through ignorance, partly through poverty, still well below an optimum food standard, and that health, growth and expectation of life would all be greatly improved if we could attain that standard.

If that is true of a community like our own, picture the gap that exists between fact and ideal in the world as a whole. Consider the implications of the fact that Africa and Asia, containing over 60 per cent. of the population of the world, enjoy about 27 per cent. of its supplies of cereals (including rice) and about 9 per cent. of its meat. The percentage figure for milk, if we had it, would be lower still.

I cannot do better than end these remarks about food standards with a sentence written by two scientists. ' If the whole of the human race, after making due allowance for any effects of different climatic and geographical conditions on maximum health, could by some stroke of the pen be possessed of, and persuaded to eat a diet constructed on the lines indicated here, then the consequent change in human health, and the resultant change in human society, would be the profoundest that have ever occurred in the history of mankind.' [2]

Turn now to the question of housing and town planning. Here in the nature of the case less exact definition of standards is possible : but we find the same general state of affairs as in diet. Systematic study of the effect on health of immediate environment, and analysis of housing standards, points towards a certain minimum individual allowance of space, privacy, fresh air and sunlight as essential for health. And secondly, by that standard a great proportion of the housing and town environment of this country stands condemned as inadequate. Take the simplest and crudest test of all, that of the Government standard of overcrowding set by the Housing Act of 1935—a standard of which the then Minister of Health (Sir Kingsley Wood) said that it did not ' represent any ideal standard of housing, but the minimum which is in the view of Parliament tolerable while at the same time capable of immediate or early enforcement.' By that standard over 340,000 houses in England and Wales were judged and found wanting. In one of our great cities nearly a third of the population were living in a state of overcrowding.

Statistical inquiry shows that improved housing and town planning has an unmistakable effect upon physique, health and length of life. A recent survey quotes the case of one of our cities, where the death rate in the slums was 28 per 1,000 against 18 in municipal houses, although in the slums there were systematic measures of house and drain cleansing, with provision of baths, wash-houses, infant welfare centres and clinics. In fact, there is nothing to do with a

[1] Mr. Morrison spoke in his personal capacity and not as a member of the Government.

[2] Bacharach and Drummond.

slum but pull it down (unless Hitler saves us the trouble) and then resolve to build better, in the sure and certain knowledge that lives and health will be saved thereby.

I will not enter on the difficult ground of housing standards—flats or cottages: family standards or individual standards; how many people per acre: how much floor space per person. I content myself with pointing out that from the welter of analysis, evidence and argument, standards are slowly emerging, and that already we have reached the point where our proven knowledge condemns as grossly inadequate a great deal of the housing now in use, in town and country, in Britain.

We are, however, not so well forward with the study of household equipment—the tools of the housewife's trade. There is work to be done in the determination of standards of fuel and light provision, kitchen and bathroom equipment, and basic furnishing for inhabited rooms. Beginnings have been made under the auspices of private industry, and progress can be rapid once systematic public attention is directed to an obviously important topic.

As to clothing, I confess I do not know what exact study may have been made of basic human needs in a society like our own: but the Board of Trade has given a flying start to exploration of this field by the system of rationing now in force. We can accept 66 coupons, and what they will procure, as a useful first approximation to a minimum—not, of course, an optimum—welfare standard in clothing. We can assume that we need to aim at a state of things in which every inhabitant of these islands can acquire not less than the equivalent of 66 coupons worth of clothing a year. And I am not sure we can assume that we have reached it yet.

When we turn to matters like education and leisure, we are moving further away from exactly determinable standards, into the realm where a community's conception of its own ultimate moral aims and purposes is a governing factor. Yet even here standards are possible, and are being worked out, for the material basis of education—the school building, the classroom, and the equipment. We have not yet got beyond the point where the school must fight an unequal battle against the social deficiencies of the general environment—underfeeding, lack of space, lack of sleep, poor health, and the pressure of family needs. By the time we have done so, and the education system can concentrate upon its proper business, we are likely to know more than we do to-day about the minimum standards it needs to adopt for its own purposes. Incidentally, the really big problem of education is to teach people intelligently to reason for themselves.

This summary review of the state of our knowledge of a basic welfare standard suggests that we have reached a state of agreed knowledge that can exert a profound influence upon post-war policy, and should already be affecting our thoughts on that subject.

In the nineteenth century political and social controversy throve upon ignorance of welfare standards. Every major social change was resisted, partly at least, on the ground that it was not needed. When Shaftesbury sought to exclude from the coal pits all women and girls, and all boys under 13, the then Lord Londonderry stoutly defended the *status quo*, maintaining that there was nothing amiss with little boys who sat underground for the twelve daylight hours opening and shutting trapdoors. 'The trapper,' said his lordship, 'is generally cheerful and contented, and to be found, like other children of his age, occupied with some childish amusement—as cutting sticks, making models of windmills, waggons, etc., and frequently in drawing figures with chalk on his door, modelling figures of men and animals, etc.' [3]

I quote this period piece as a typical example of a kind of political controversy which should be gone for ever. It is more difficult nowadays than it once was to contend that people are as well off without fresh foods and adequate housing. If political leaders make proper use of the truths which the scientists have unearthed, one of the last refuges of anti-social vested interest is destroyed.

This brings me to a point I am anxious to make. The scientifically determined welfare standard is, I believe, a key to one of the oldest and most baffling problems confronting democratic statesmanship. Always and interminably, the political leader in a democracy finds his path beset by the temptations of demagogy. So often there is conflict between what will appeal to people—what they will comprehend and respond to—and what is really required for social progress. The scientific welfare standard is, I think, the answer. It has both popular appeal and practical validity. It provides a bridge between sound technical politics and mass comprehension. You cannot perhaps induce the great majority to take an impassioned interest in ways and means, but ends they can be led to understand. I believe in the practical possibility of achieving profound social change, by consent, once a democratic society is brought sharply up against an objectively determined welfare standard, which it is demonstrably not attaining. Statesmanship can then concentrate upon bringing the proven facts into the light of day, until they become a touchstone of men and measures. Given agreement that a certain standard must be a first charge on the income of a civilised community, certain other social aims and processes will stand condemned as incompatible with it. Society is a large family which must make a living. As soon as the members of the family can agree upon the kind of living they feel to be necessary as the basis of the lives they want to lead, it becomes unthinkable for some of the members to enjoy a luxury standard while others have not attained the minimum.

Then we come to political methods. I do not pretend that one particular political doctrine holds the whole key to the post-war problem. I do think, however, that a greatly increased measure of centralised planning in the communal interest will be called for.

This fact will confront Government and society with two issues, issues which will, fortunately, be inescapable.

[3] Hammond: *Lord Shaftesbury.*

First, the issue of ways and means by which the optimum standards can be reached. This involves a study of the possibilities ; the making of programmes ; the organisation of labour, mental and manual, and the accumulation and direction of capital expenditure to the given end. It may well mean sacrifice—the sacrifice of a short-lived present to the interests of an assured and noble future. And there will be no sacrifice if there is no social discipline and courageous and far-seeing political leadership. The politician with his ears to the ground must give way to the statesman with his eyes on the future. Second, the issue as to what is practicable meantime. As to that the political parties—all of them—will have a national duty to be honest. The Dutch auctioning of the political market place will be a social danger in the post-war world. Promising the impossible for vote-catching purposes should be frowned upon by political leaders and people alike. 'Join with us in a mighty effort for a Britain freed from poverty' is a better slogan than 'Vote for us and see what you'll get out of it.'

For the purpose of ascertaining what is practicable in the transition period Parliament ought to have placed before it an economic or industrial budget as well as a financial budget. Let the facts and the deductions from them be argued about by all means, but let us have facts rather than abstractions. And on those ascertained facts let us decide what is the highest minimum standard of life that is possible.

Parliament will have a busy time in those trying post-war years. If I am not mistaken, much legislation will be required. Efficiency and speed will be vital if democracy and orderly progress are to survive. The war has taught us much in this connection. I conceive that it may be necessary and desirable for Parliament to keep to itself those aspects of legislation which concern the fundamentals of policy, principles, finance and the broad rights of the individual, but to delegate to Ministers considerable powers in respect of the more detailed matters by means of Orders in Council. Leisurely parliamentary sessions debating the minute details of only two or three major Bills a year will not do the job the nation will require from its parliamentary institutions.

We had better face the fact that the slow-moving mechanism of nineteenth-century formal democracy will not meet twentieth-century post-war needs. If democracy is to survive, it must grow up. A democracy that 'stays put' is a democracy that is asking for fascism.

But no one will suppose that a problem of this sort can be tackled on a national basis alone. The rise of extreme nationalist economics during recent years has brought its inevitable result. Any society that concentrates upon the achievement of a welfare standard to the exclusion of—and worse still, at the expense of—other groups, contains within itself the seeds of dissolution and war. The real impulse behind any movement to achieve such a standard is a moral impulse—the recognition of human equality of social opportunity—and it cannot stop short at national or imperial frontiers.

Looked at in this light, the scientifically defined welfare standard creates the opportunity for international co-operation instead of affording occasions for destructive competition. Within the limits of our own Empire we have, in the colonies, a field that cries out for development on these lines. Last year's White Paper shows how far the country is ready to move from the old notion of colonies as an imperial estate to the new conception of the need to build up their internal trade and economy, and to raise their standard of life, no longer for our sake but for their own. Yet such a policy is wise in our interests too, for a country which must live upon world trade can only thrive upon increase of world welfare. What is true of our colonies in themselves and in their relation to us, is true of every economically backward country in the world. All of them await the help that we can give. Assuming the avoidance of cut-throat competition by the general adoption of some adequate minimum standard all of them will repay such help by enriching a common international economic life from whose benefits we ourselves cannot be excluded.

Again, what is true of Britain is true of the United States of America. There is but one basis upon which the economic relations of Britain and America can avoid collision and shipwreck after the war—the conception of positive economic welfare as the mainspring of policy at home and abroad. In this both partners can find an outlet for 'surplus' materials, fantastically so called, and 'surplus' labour—the adjective should be equally nonsensical.

Lastly, I maintain that in serving and achieving the standard with which I am dealing lies the only hope of appealing to the constructive instincts of mankind—instincts which, left unexpressed, turn in upon themselves and create ruin and destruction. Highly developed peoples require a social aim. The British people, who have colonised a great fraction of the world and travelled, traded, and fought over most of the rest of it, will certainly not settle down calmly to a life without opportunities of growth. From now on those opportunities can no longer be geographical : they must be social. One of the main outlets will be at home : there the urge to expand and to create will find its primary satisfaction. Its aim will be the realisation of an ideal which the instinct of common men and the trained judgment of the expert unite in pronouncing good. That is the ultimate significance of the standard of human welfare as science has defined it.

The question is : shall mankind become the master of material things or shall it continue to be tossed hither and thither by surging and misdirected economic forces ? Both our dignity and our interests require that we shall be the directors and not the victims of technical and scientific advance.

Dr. Wilder Penfield

Orientation of Scientific Research to War

To speak to a symposium on science and human needs is nothing unusual for a medical man. This is the subject of his customary preoccupation. It is, however, strange that even the physician must accept a reinterpretation of the nature of human needs. Defence of a besieged country,

deliverance of mankind from enslavement, the winning of this war—in these propositions are to be found the human needs of to-day. Old responsibilities must still be accepted by our profession, but medical research should now be directed toward the essential problems of defence, and even, by a strange transformation of medicine, toward the problems of offence.

Biological sciences march with the physical sciences in their academic crusade, and the things I am about to say may be taken to apply to science in general.

'What has become vital . . . is the capacity for initiative, invention and endurance,' to use the words of the Canadian Commander-in-Chief, General MacNaughton.[1]

In September, 1939, Wilfred Trotter [2] wrote: 'That our superiority of strength lies chiefly in the realm of the mind is a truth of which we suppose our rulers are aware. They would do well, however, to bear in mind that really effective thinking is the most difficult of all human activities, and very easily inhibited by professional and official conventionalities. It is, however, more urgently needed in this war than anything else.'

What I would like to call to your attention this afternoon is that they might do well, also, to bear in mind that they may, if they wish, call upon the whole English-speaking world to contribute to this strength, and that, on the other side of the Atlantic, although inhibitory agents do exist, they do not fall from the sky.

Professor A. V. Hill, after a trip to the United States in the first year of the war, found that there was 'no section of the public so unanimously concerned for the victory of British arms as the community of university and particularly scientific people.' [3] It is true, they are concerned, but they are not mobilised in the way that they could be.

In Germany, however, science has been more than mobilised: she has become the handmaid of a dictator, the principal agent of death and destruction, a new Ariel who whispers propaganda for her master and weaves the net of the Gestapo. But the enslavement of science within Germany began long before Poland heard the sound of marching feet and the roar of the strange scientific armaments. It began with the beginning of the Third Reich, and the declaration of war against freedom of thought is to be found in *Mein Kampf*.

Four years ago I revisited a distinguished professor in a certain German university. I found him in a splendid institute. But the science of this institute was the science of peace, and as we walked through floor after floor our footsteps echoed from empty laboratories. Seated in the room of the ageing professor, with doors carefully closed, I learned only that there were no longer any assistants. Young men were busy with military service. Pure science was dead and my old friend had bowed to a new order—an order of scientific enslavement.

In the free countries that are at war with Germany—both declared and undeclared—thousands of men on university staffs, men specially trained, are now looking toward this mortal conflict wondering how they may make some contribution. Why do they not know what these problems are? No doubt it is because those who know are preoccupied and because the secrecy which is necessary in some cases has swallowed up all deliberations. In spite of the efforts of the research councils in the United States and Canada, the waiting scientists have been treated a little like the 'wicked generation' to whom no sign is given.

There are two ways for a government to get important help from science: first by delegating the problem to the individual worker, a sort of penny-in-the-slot system, but effective nonetheless: secondly, by the reception of suggestion from independent investigators.

The first method—that of specified research—has been used in Germany, and no doubt is being used, to very good purpose. In Britain, this type of medical research, much of it of a secret character, is being carried out, for the Air Force and the Army, by the Medical Research Council under the able chairmanship of Sir Edward Mellanby. From the point of view of an observer lately arrived on the scene, I can say that this work is practical, efficient, sometimes brilliant, quite reassuring from the point of view of the future.

Special physiological research laboratories have even been built where they are in direct contact with the operation of aircraft and of tanks for the study of the problems of personnel. This is an example which has not yet been followed by the Navy and by other departments of the Army.

Perhaps it may be of interest to refer briefly to the organisation of war research in Canada.

The National Research Council, as originally set up, may be considered the Canadian counterpart of the British Department of Scientific and Industrial Research, D.S.I.R., and the Agricultural Research Council. Working with an experimental budget of 5 million dollars, its activity is now directed almost completely toward problems related to the national emergency.

What may be called the Canadian counterpart, in a small way, of the Medical Research Council is the Associate Committee on Medical Research of the National Research Council, of which Prof. J. B. Collip is now chairman. This was organised a few years before the war by Sir Frederick Banting, who became its chairman. Thanks to his genius and energy, close co-operation was established with the medical services of Army and Air Force. Research work was stimulated in various Canadian universities, most important of which was that carried on in Banting's own Toronto laboratories which were completely turned over to the problems of aviation medicine. His death occurred in the first crash of a transatlantic bomber last spring, when he was flying to Britain for the purposes of exchange of information.

Although specified research may be the first and most obvious way in which government can secure aid from science, the second method, the reception of suggestions from scientists who work independently, is another and most important channel of assistance. This is possible in the

[1] *J. Roy. Soc. Arts*, **89**, 492, 1941.
[2] *The Times*, Sept. 26, 1939.
[3] *Science*, Vol. 93, No. 2425, June 20, 1941.

English-speaking countries to-day, where native wit and freedom of individual expression can be counted on to strike the spark of occasional brilliant discovery. After all, the great advances have not been the result of specified research. What Government official or research council would have had the wit to apply to Newton for an explanation of why a body falls to earth or to turn to Boston for the boon of anæsthesia or to Toronto for a cure for diabetes?

This method of reception of scientific contribution is only possible in the democracies. To capitalise it, those who know must make clear statement as to what problems are important, and, furthermore, the universities on the other side of the Atlantic must be informed directly as to the nature of those problems. This can be done without undue loss of secrecy, and it is more important to anticipate the enemy with new discoveries than it is to preserve secrecy at home in regard to those methods of which the enemy already has full knowledge or which are out of date.

If channels are kept open for the reception of unsolicited advice from errant scientists and pseudo-scientists, the research councils must afford a protective barrier to sift out the wheat from the chaff. Even in a democracy gratuitous advice may well be irritating.

For example, a surgeon might suggest that methods of evacuating wounded in this war should be altered as radically as have the methods of warfare. A large squadron of ambulance aeroplanes will be required, and no doubt provided, when the supply of combatant planes is great enough to make possible new phases in this war. With this possibility in mind, it might seem that there should be in operation in the Middle East a small air ambulance service, even on an experimental basis. It would save life, improve morale, and, most important of all, it would serve as a basis for later expansion without the inevitable mistakes of initial organisation and selection of aircraft types.

In my opinion, the time to conduct the experimental construction of a small air ambulance service is now, so that later expansion may occur without muddling.

It is necessary to take steps to activate sources of suggestion in the universities on the other side of the Atlantic. They are, as yet, little disturbed by the dislocations of war and also they are not yet awake to their own opportunities.

On the other hand, it is true that the universities in this country are carrying on in a magnificent manner. They are teaching, one may say, as well as ever, and wise governmental provisions have maintained an adequate population of selected students. But spontaneous research has almost stopped in these universities, with a few exceptions. Young men have other duties, and the professors bear a staggering load of teaching.

If the universities in the United States and the Dominions were properly informed, they might well take up the torch of practical research. The rest must be left to their initiative, for it is spontaneous research that is sought.

The Faculty of Medicine of McGill University passed a resolution which in some form might well be acceptable to other faculties and to American as well as Dominion universities. It read, in part:

'To-day the very existence of academic freedom throughout the world is threatened. University science has contributed much to the technique of war in a totalitarian state. Opposed to the military machine of that state are arrayed the resources and the initiative of free peoples. The balance is close, and every scientific contribution may be of importance.

'Be it resolved, therefore, that . . . each Department of this Faculty should now give further thoughtful consideration to the abilities and preoccupations of the members of the staff, in order that the attention of those capable of effective research may be directed toward practical medical problems which face the army, the navy, the air service, and the civil population behind them.

'This re-examination of departmental activity is recommended to each department in order that less important work may be discouraged, and so that all of the scientific initiative of which this Faculty is capable may be turned toward the single purpose of defence of a besieged country and the defeat of a military organisation which threatens free institutions everywhere.'

Democracy was never in greater peril than it is to-day. If its superiority lies 'chiefly in the realm of the mind,' let us have a more complete academic mobilisation; for 'democracy,' to use the words of Prof. R. H. Tawney, 'is a kingdom to be won, not a possession to be enjoyed.'[4]

Prof. William G. Holford

The Use of Land in Town and Country

IF planning is to be anything more than a design on paper, it must be the framework and the method by which the sciences relate to human needs. The branch of planning known in this country as 'Town and Country Planning' takes on significance as soon as this principle is admitted and applied; without it, a negative attitude prevails and planning remains either a pious hope, or a mere administrative convenience.

Town and country planning is chiefly concerned with the right use of land for a variety of human purposes. Very broadly, I should group those uses as (*a*) Agriculture, including forestry; (*b*) Development of all kinds, including industry and building; (*c*) Recreation; and (*d*) Transport.

I think it follows that agricultural science, building and engineering science, the social sciences in general and the scientific study of traffic, are four fields of research in which technical contributions to the art and practice of town planning may be made. These are in fact the elements of planning which were defined at the beginning of this century by Patrick Geddes as Place, Work, Folk. Since Geddes' day, however, the capital difficulty with which the town planner has to contend is not so much the lack of recognition of the human values affected by it as the fact that these values are still considered in compartments. And here, at the root of the matter, are two hindrances to progress, which

[4] Letter to *New York Times*, reprinted as *MacMillan War Pamphlet No.* 13, 'Why Britain Fights.'

need to be overcome if the reconstruction of towns and the replanning of environment, not only in England but in other countries, after the war is to be real, effective and lasting.

Firstly, in the field of research, science should be systematically related to the practice of town and country planning in each one of its particular aspects ; and, secondly, in the field of policy and administration, the co-ordinating function of planning should be recognised and valued. Just as architecture co-ordinates the specialist elements of building into a design, so should the planner co-ordinate specialist forms of development. A well-known agricultural scientist remarked recently that ' there is scarcely a Ministry of State which is not in effect a great technical department, and yet the implications of this fact have not been clearly understood.' Nor is it understood that to hold a balance between the conflicting claims of industry and agriculture, and to relate all forms of development to a plan which is drawn up to make the very best possible use of land in the national interest, an independent authority will be required, which will be thoroughly well informed about resources, properly equipped to give positive guidance to local planners, and strong enough to prevent abuse.

I think that part of the misunderstanding is due to the word ' planning.' A plan is drawn by an architect for a house ; by an engineer for a road ; a farmer works out a plan to convert his grasslands to arable or ley farming ; a landscape designer does the same for a park. All this is planning in a special sense ; but not in the general sense that I have referred to as town and country planning. In this the planner has to discover not so much how to use a piece of land for a special purpose, as what purpose out of many is most suitable to it and to the general pattern of the region. To do so, he must have regard to its past history and to its present state, as well as to its resources and its future possibilities. Hence the value of disinterested scientific advice for the planner as well as for the developer ; and the importance of distinguishing between ' planning ' and ' development.'

At the other end of the scale there is confusion, I think, between planning and policy, which frequently arises when ' national planning ' is mentioned. In the wide economic and strategic sense, planning again becomes a form of development, but on a national or international plane. If it becomes necessary, for instance, to promote exports, even at some cost to home farming, to build a military road or an airfield, to facilitate the purchase of land for playing fields in the middle of towns, or to require some form of district heating in city blocks so as to reduce smoke and economise in fuel, then the apparatus of planning must be ready to accept policy decisions ; and ready also to point out the cost and the consequences of that policy in so far as it affects land and the pattern of population upon it.

This may appear to some people to be an understatement of the case for planning—to distinguish it from development on the one hand and from policy on the other. But the surest way to render it ineffectual is to blow it up to unmanageable size, or to regard it as a panacea for every social ill. It is better that, in theory at least, town and country planning should occupy an intermediate position ; basing its information on the widest possible research ; and setting out a flexible pattern of living and working, that will be a serviceable instrument for use, rather than a ready-made formula.

In practice even these limitations will partly disappear. Every technical advance that is made in the field of development alters the pattern of the plan, whether it be a new medium of transport, or an improved method of land drainage, fire protection or building construction. The same is true of social changes, such as improved education, holidays with pay, slum clearance, or communal feeding. So that while it is true that planning should precede and to a certain extent govern development, it is itself dependent on development, and should always be in close touch with its progress. In the second place, I think there is unlikely to be a serious gap between planning and policy. The making of even a preliminary plan based on a survey usually means the drawing of some sort of sketch map ; and to this map the interested parties are drawn like needles to a magnet. Discussion ensues and alterations are made. The scheme, as tentatively agreed—and very often agreement is facilitated if not actually secured by the planner himself—goes forward as a proposal. It is true that considerations of policy may override that proposal : but I think it is difficult to say to what extent plans suggest policy or policy is anticipated by plans. In any case, there must be a two-way communication between them, as every research worker knows.

The important point to recognise is that planning can perform a useful and necessary function, even before a fully determining situation arrives, if in fact such a situation may be expected to arrive at all.

Meanwhile, even those objectives which are universally acknowledged as necessary or socially desirable are still a long way from being achieved, as we have heard from more than one speaker on this platform. The waste of land is one of them, whether derelict grassland on a farm, pits and spoil-heaps in industrial areas, or unnecessary duplication of roads in the middle of a city. Social waste is another, whether it is in slums or in the 12 to the acre desert of a housing estate, which has no social centre and no community sense whatever. Plans to demonstrate how this waste can be avoided are one of the steps towards the co-ordination of land use generally : and it is high time that these plans were prepared.

To sum up, at a time when normal development is held in check, an opportunity presents itself to consider, on the basis of our existing national resources, the best use of the land and the most convenient and desirable pattern of human settlement upon it.

This survey should be the product of a series of related surveys carried out by Government departments, with the very best scientific advice which is available to them. It should be carried out now. It should carry these particular researches a stage further—to the point where they can be co-ordinated by a central authority on the basis of land-use, in order to form a provisional master-plan for physical reconstruction.

If, in the course of that investigation, the agri-

cultural, the social and the industrial scientists disagree on occasion—as they will—it should be the planner's duty to remind them that, although 'there will always be an England,' only one terrestrial example of it exists ; and its land is the common platform for all their activities.

Mrs. Mary Agnes Hamilton

As a representative of the mere consumer, to whom this great assembly, with characteristic generosity, has allowed a word, I want to enter the discussion at a point made by Sir Harold Hartley. He said, and of course with truth, that the scientific use of power had not only revolutionised labour conditions : it had to a large extent lightened toil, increased comfort and improved health within the home. So far, however, that beneficial relief has been limited, in the main, and in this country, to the well-to-do home, the modern house and flat : the great body of working women are still coping with the old dirt, the old drudgery, the old appliances. They are working, that is to say, under conditions that make it extremely difficult for them to find, in their work, that artistic satisfaction that belongs to any work which is done as well as it can be done ; they are working under conditions that take far more of their time, of their strength, and of their temper than need be used. My plea therefore is for the extension to the average home of the labour-saving appliances that could revolutionise life within it. Something has of course been done to this end by progressive municipalities ; but we have to go to Sweden, and to Vienna and Prague, as they were, and please God, will be again, to find the full employment of contemporary convenience to the service of the poor home, although it is in that home that the woman has to do the work herself, as well as look after the children. Still, in the vast majority of such homes, in Britain and even in America, the woman's daily task is far heavier than it need be. She brings to it an infinite patience ; she produces results that, in the conditions, are often amazing ; but there lies on her a burden that taxes her health and limits her happiness. Could the average working-class home be equipped with the labour-saving devices and the aids that are to-day available and installed for the large establishment a difference hard to measure could be made in the life within it. If, universally, gas and electricity were installed for domestic cooking, heating and lighting, and serviced with chromium and bakelite fittings, the cleansing of our drab skies would, at the same time, remove that omnipresent and soul-destroying dirt that is the constant enemy of woman-kind ; the standard of cooking could go up and the conservation of food values with it. But this is not all. By thus lightening the domestic load we should release, for their own happiness and for the service of society, varied capacities now largely wasted through undifferentiated use.

This is the kernel, to my mind. The world is going to need all the work of all its citizens in reconstruction. It is going to need the work of its women as of its men. If work within the average home were rationalised—for this, and no less, is what the application of science to its varied problems could do for it—the woman who wants and is fitted to do a job outside could do it, without sacrificing her home. Its daily running could be overtaken in a modicum of time. For its more serious tasks, no longer of the haphazard ill-thought-out kind inevitable in an occupation no one has thought worth organising and to which no special skill is thought to attach, but now capable of orderly planning, there could be called in a professional—one whose talents lie that way. After all, although most women care for their homes, not all are gifted with the talent for domestic work ; for those who are, here is a career : with the dignity that goes to any skilled work. Does this not open an obvious path to a genuine conservation and better direction of energy ? Nor is the home, as focus and centre of life, going to suffer ; on the contrary, it stands to gain immensely. The lightening of unending and largely needless toil will enable the family dwelling within it to enjoy a fuller and freer companionship, at once richer and more varied. Science, if not too proud to promote this lowly application of its great achievement, will make no mean contribution to what Dr. Thomas Jones the other day called the 'thousand little victories around our own doorsteps into which our victory must be broken up.'

Prof. A. C. Egerton, Sec. R.S.
Material Economy

My object is to draw attention to those factors on which the material welfare of the human race depends. In any recasting of the world order, those things must have first consideration which make life possible. Although it may not be possible to draw a distinct line between those material things which are essential to the working of the human body and the many more subtle aspects of life associated with man's mind or spirit, yet there is a fairly distinct domain in our economy in which material factors are dominant and another in which psychological factors predominate. It is only some of the material factors to which I wish to refer here, and thereby to point out the essential unity of those subjects which have been discussed by Sir John Orr and Sir Harold Hartley, viz. food and fuel.

There are two main considerations. The first is that practically all the energy available to us at present is derived from the sun. Radiation from the sun continuously bombards the earth, providing energy to it at the rate of 13 calories per minute per square inch at its outer boundaries. We need not consider here what happens to this energy, but it enables plants to live and animals to live and both provide food for human beings. The sun's radiation is the source of our food, our warmth and our power. We not only make use of the energy that we are receiving now but also that which has been stored away by vegetation in past ages as coal and oil. It probably took 10 million years to lay down in store for us the fuels which are now being used up at ten thousand times that rate. On a planet where conditions were not suitable for the storage of the products of past vegetation, the direct use of the sun's energy would be encouraged ; wealth would depend on making the most of the energy of solar radiation, waste would be the squandering of it. That was very much the condition on the

earth until the time of the Industrial Revolution ; since then coal and oil have been drawn on to supplement the energy derived directly from solar radiation. That was a fundamental change in material economy. To-day the world makes use of coal to the extent of 1,300 million tons per annum, of oil 270 million tons, and natural gas is used to the extent of 55 million tons. The consumption of the last two is increasing, that of coal remains fairly steady. We only make use of a small fraction (1/60000th) of the solar radiation ; some of it is fixed by photosynthesis by plant life and is harvested as food, some, through the atmospheric mechanism, is collected as hydro-electric power.

If ever the vast stores of energy in the make-up of atoms can be released, controlled and used, that will be another Industrial Revolution bringing with it great advances but also troubles which may be as undesirable as those which attended the former revolution, unless they are envisaged and countered in good time.

The second main consideration is that each human individual needs a certain amount of energy as food in order to keep alive and do his work : the amount required is between 2 and 4 million calories per day (depending on work, age and other things). In these days of vitamins, one needs almost to apologise for referring to the crude energy requirements of the human body, but in times of stress, those basic requirements are brought home to us. Besides energy, the body needs water, nitrogen, phosphorus and many other of the elements in more or less degree essential for life, but the energy requirements outweigh in economic importance all other factors, many of which are included in the food needed to provide the energy.

By cultivation, the farmer can reap more energy than he himself needs to expend in the getting of it, and others can live on the results of his labour as well as himself, and so the population grows. The stored fuels enable a still greater growth of population. The miner brings coal to the surface with far greater energy content than is spent in the getting of it. This energy enables metals to be won, and other goods to be produced to exchange for food. The fuel provides mechanical power which supplements manual labour, which means that less labour is needed to provide a given amount of total food.

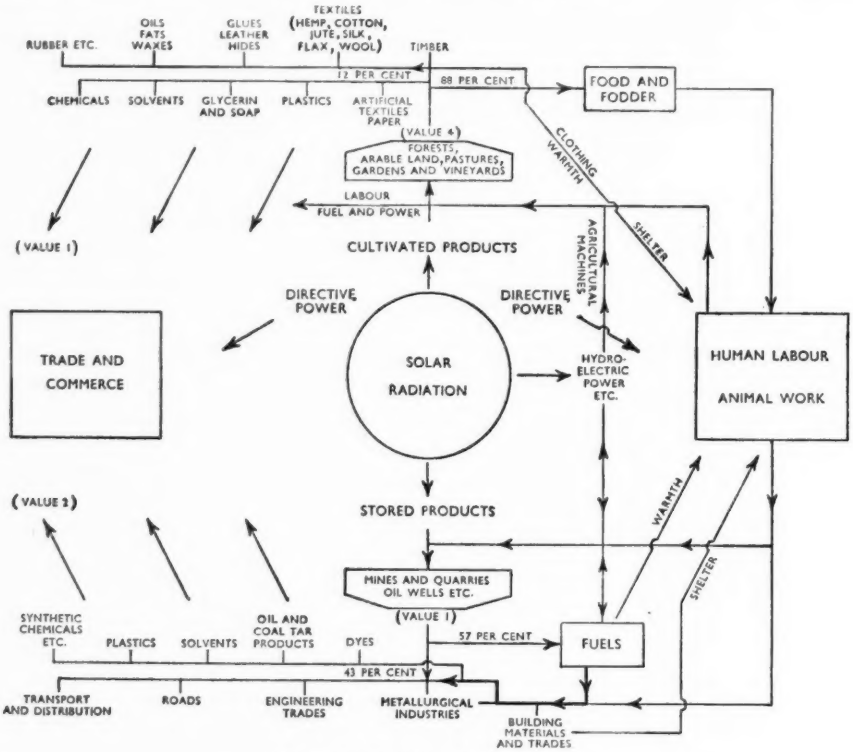

DIAGRAM OF HUMAN ACTIVITIES

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In the world to-day the mechanical power employed is not known for certain, but one might roughly estimate it as not more than 100 million horse-power. The total manual and animal power is not less than a tenth of this, and it is probable that the two sources of power manual and mechanical are much of the same order. If there were no regulation of the amount of fuel won, so much mechanical power might be used that a state of affairs in which people are happily employed might not be maintained. It would seem that if the world is to be happy, a suitable balance should be maintained between the food produced and the fuel used to supplement the labour employed in getting it. Last year I tried to set this all out in a sketch plan of human activities given in the Hawksley Lecture (1940) to the Institution of Mechanical Engineers, and it is here repeated with some further explanation.

Energy reaches the earth by radiation from the sun. It provides stored products—the coal and the oil—on the one hand ; on the other hand, products of cultivation from forests, farmlands, orchards, gardens. It also supplies water power.

Human activities are mostly engaged in getting the products of cultivation ; four times greater is this activity (as measured in gold value) than that of all the other activity. Of this activity in cultivation, it has been estimated that 88 per cent. is in the production of food for man and his animal helps, 12 per cent. for all the other things (textiles particularly).[1] The food and the fodder go to keep alive and to provide the energy for human labour and the work of man's helps (horses and oxen). The work done by the human and his mates goes mostly into the cultivation of the soil (upper half of diagram) but also partly to get fuel, building materials and to make all sorts of things and carry them about (lower half of diagram). It is stated that about 57 per cent. of this latter activity is in fuel getting, and 43 per cent. for all the other activities mentioned in the lower half of the diagram. The fuel is needed to provide power and so to supplement human labour. (It displaces the need for more food to provide more human work for the same total output of work.) Fuels are also needed to provide heat to win metals and chemical products, but those functions are part of the provision of extra mechanical power, for they make possible the use of such power. Fuels are necessary to provide warmth to keep life going in the colder climates, and part of the activity included in the upper and lower halves of the diagram is needed for a similar reason to provide shelter and 'lagging,' viz., buildings and clothing.

Power derived not only from human labour but from fuel and water power is used for winning the cultivated products and the stored products. The products of industry in the lower half of the diagram are exchanged for food and other cultivated products referred to in the upper half of the diagram ; the total value of the products of industry is twice that of the products of cultivation, apart from the foodstuffs.

As the world gets more and more involved in these activities, the number of humans employed in directing all this activity becomes greater. (This work is not part of the manual labour which has its source in the energy of food, but food is needed to maintain the metabolism of these directing-workers.)

The more fuel that goes to make mechanical power, the less human labour is needed for the same total world activity and the same total population ; so that for a stable state of affairs, a balance is needed between food and fuel production : the standard of living and the hours of leisure are affected by the relation between the two.

The diagram also illustrates that the energy of coal is as it were 'upgraded' into products of higher value by manufacture and products of cultivation are 'downgraded.' Substances can be synthesised or broken down—for instance, alcohol can be got from the oil or carbide industry on the one hand, or from the fermentation industries on the other, and one may 'pay' better than the other. What is most profitable is not necessarily most desirable. The energy of food is 'downgraded' in the process of keeping the mechanism of the body in action. General efficiency—by that one means making the best use of what the sun affords us—depends not only on the efficiency of the 'upgrading' processes, but also on that of the 'downgrading'—in other words, the health and efficiency of the worker.

Much of this is commonplace, but I have tried to picture it as one whole from a point of view which does not seem to have received sufficient attention in the past. Energy, as already pointed out, is not the only consideration ; water, for instance, is necessary for life, and one might well view the world's use of that necessity in a somewhat similar way.

My plea is that in preparing for a new world order, it is necessary to have more accurate knowledge of the material resources of the world, and particularly the sources of energy, and to plan on the basis of that knowledge. It is no use to lay down a power scheme here and a land reclamation scheme there without reference to the general world layout in relation to food and to fuel. There should be in each country a body that gathers the necessary statistics as to fuel and agricultural products, and real importance afforded those bodies such as the World Power Conference, and some reconstituted International Institute of Agriculture, so that true information may be obtained from the various countries which can then be collated and made available through an authoritative body to the statesmen of the world. The object would be to prevent the repercussion on general economy which the blind sway of vested and political interests has produced in the past.

If access to the raw materials of the world is to be shared on an equitable basis, then we must be assured that those raw materials are used to the world's benefit, and not simply for the limited wealth of certain sections of its population or of certain regions. Chief amongst the raw materials are those which provide the energy requirements of man. The poverty of certain tropical islands is an illustration of the chaos that comes about by the uncontrolled utilisation of energy. From the solar radiation in the tropics, so much exportable foodstuff—sugar, for instance—is produced in times of boom trade that the population increases to so great an extent that the island may not be able to support itself in times of slump. Such a state of affairs should not occur, if statesmen had the guidance which they should be afforded. In Mr. Eden's words, 'if we are to remove the fear of want as well as of war, science and statecraft must work together.'

Finally I shall quote from a statement by the Archbishop of York : 'Nature is man's partner rather than his servant, he is dependent on it for the means of life. . . . The treatment of the earth by man, the exploiter, is not imprudent but sacrilegious. We are not likely to correct our hideous mistakes in this realm unless we can recover the mystical sense of oneness with nature. I labour this precisely because many people think it fantastic ; I think it is fundamental to sanity.'

[1] Sir H. Hartley (1937), *Jl. Textile Inst.*, vol. 28, p. 151.

SCIENCE AND WORLD PLANNING

SATURDAY, SEPTEMBER 27 : MORNING SESSION

CHAIRMAN : H.E. THE SOVIET AMBASSADOR, M. MAISKY

The Chairman

IN opening the third session of the Conference this morning I must confess to a certain feeling of diffidence. There are two reasons for this.

In the first place I have to face a distinguished array of great scientists whose mental movements very often proceed on the plane of eternity—they investigate and discover the permanent laws of nature and their minds are always turned to things perennial. And now over this august assembly has to preside whom? A humble Ambassador who knows nothing about anything, who in his professional capacity is a complete negation of stability and a true embodiment of constant fluctuation. An Ambassador of our days lives in a kaleidoscopic world in which every *point d'appui* immediately turns out to be shifting sand. Diplomatic life of our time is strange and fantastic, and the motto is 'every hour a change.'

My second reason for diffidence is the very subject of this session. It reads 'Science and World Planning.' The subject is tremendous and tremendously important. There will undoubtedly come a day when the system of very comprehensive planning—economic, social, political—will embrace the whole globe. But this day is not yet very near. I come from a country where planning is the very foundation of its economic life. In this the Soviet Union has reached already a very considerable degree of perfection and it was no easy matter. It took us more than twenty years to build up the present system of planning, in spite of the fact that since the early days of our revolution we had not to reckon with the difficulties which originate from the existence of private property on means of production and distribution. Such was the position in a single country with a strong and unified central administration. How much more difficult it will be to bring about economic planning on a world scale! How long it will take to create the necessary pre-requisites for the success of such planning! Obviously this is a matter for not to-day or even to-morrow.

Yet I think that the problem of large-scale planning in international affairs will become acute very soon after the war is over. When the order to cease fire sounds and the restoration of peace conditions begins, I have no doubt that the burning question which will animate millions of human beings all over the world will be: how to escape the repetition of the great catastrophe through which we have just passed; how to secure immunity from war to our children, and to the children of our children. There will be no more important and passionate question than this. There will be no other question on which so many, and with so much intensity, will think. And once this mental process begins it will inevitably, although perhaps not immediately, lead these millions to the recognition that the only road to salvation is large-scale planning in international affairs, with all that it implies. Then the various branches of science will play a tremendous rôle in the creation of the new world. Then our experience, the experience of the Soviet Union, will greatly contribute to the solution of the problems with which peoples will be confronted.

However, this is the music of the future. We should not lose sight of these distant aims and tasks, but we should never forget that good English expression: first things first. I fully agree with Dr. Negrin, who yesterday said: 'Before you drink your wine, you must first procure your grapes.' We are now in the midst of a tremendous conflict in which three-quarters of mankind are involved. This conflict concerns the future of humanity, and, if Hitlerite Germany wins this war, there will be no freedom, no democracy, no culture, no science, no planning in the world. There will be only one huge prison throughout the length and breadth of the planet, in which all nations will be herded together like slaves under the whip of the most brutal and unscrupulous gang of all times.

In these circumstances the most imperative desire of every freedom-loving man and woman must be to wipe out this terrible menace, to crush Hitlerite Germany. There is no more pressing task. Science and men of science must also play their part in this tremendous undertaking. We in the Soviet Union never believed in so-called 'pure' science. We always believed that science must help humanity in its needs. And what is the most important need of humanity to-day? To destroy the system of German

Nazism which wants to dominate and to terrorise the whole world. Science and scientists cannot and will not escape their duties in this most terrific and, if I may say so, most ' scientific ' of all wars. They must help to solve the immediate problems of to-day. I would like to see therefore the present Conference in general, and the session over which I am presiding this morning in particular, take close to its heart these questions and problems which are most important in order to crush Hitlerite Germany and to free mankind from the terrible menace which overhangs it now.

Rt. Hon. Lord Hailey, G.C.S.I., G.C.M.G., G.C.I.E.

I SHALL not occupy much of your time by way of preface. It is necessary only to explain that in speaking of colonial conditions I shall in the main limit myself to those prevailing in our own colonies, with their population of about 50 millions. It is not perhaps generally realised how greatly the character of our colonial empire was modified as a result of the expansionist policy of the latter part of the last century. The Indian Empire and Burma have, of course, never been ranked as colonies. Up to about the eighties of the last century, therefore, the colonies comprised mainly Ceylon and a small part of Malaya in the eastern hemisphere, a number of trading settlements on the coasts of Africa, and in the western hemisphere our old possessions in the West Indies. I leave out of account the various stations, mostly of small area, held for naval or strategic purposes. The period of expansion added in Africa alone an area roughly equal to that of British India, together with parts of Borneo, an extended area in Malaya, and some of the Southern Pacific Islands. I give these facts because they have some significance for my present purpose. It is not merely that the new territories were largely tropical in character. It is more important that the majority of their populations were at a stage at which they had needs, both material and social, far greater than those of some of the older dependencies. Judged in terms of approach to our own type of civilisation, they were far more backward. On the other hand, we had then available to us the result of much previous experience of colonial development ; above all, we had by this time at our service an amount of knowledge regarding the employment of the applied sciences in social development which was far in advance of that possessed by our predecessors. We had another advantage. Earlier in the last century, tropical products (excluding, of course, certain of the minerals, and the precious metals) were in demand only in the luxury market of the more highly developed countries. But the rapid growth of standards of living in those countries has made the luxuries of our grandfathers the necessities of whole populations to-day. Such things as cocoa, the great range of vegetable oils, coffee or bananas, are typical of the tropical products which have become essential to the general population of Europe and America, and thus can now assist the tropical peoples in financing the social services needed to improve their standards of life. Let me add one further potential advantage. We had also at our service a growing store of knowledge about the social customs of primitive peoples. The term, if not strictly accurate, is at all events convenient. It may be that the existing customs of these peoples in such matters as the holding of property, the regulation of conduct by tribal or community ties, and the like, have had their analogy in the past history of our own and other highly organised peoples. But we are now divided from the primitive peoples by a gulf which makes the process of their adjustment to modern civilisation far more difficult than that of many of the Eastern peoples. Our anthropological study may, at the period of which I am speaking, have been interested in the form rather than in the function of custom. But we had here the means of appreciating the fact that the gulf could not be suddenly closed by a hasty substitution of our own social conceptions and practices, but must be bridged by a studied adaptation of existing custom to modern uses.

I can best illustrate the character of the problem with which I have set out to deal, if I ask how far we have actually availed ourselves of these opportunities in planning the development of the new areas which the events of the latter half of the last century brought into our possession. We need not concern ourselves here with the preliminary stage through which all colonial development must pass, I mean the introduction of law and order, and the provision of those more elementary requirements, in the form of communications and the like, which will enable the population to begin building up its material existence. We are concerned here with the secondary stage, of which the chief feature is, or should be, the conscious planning of the improvement of its standards of life.

We can afford to avoid at this point any discussion as to the nature of the ultimate objective of this development ; whether, for instance, we desire to europeanise the dependent peoples, or what is the nature of the synthesis between the indigenous culture and our own culture which we seek to attain. These are no doubt questions which must have their answer at some stage, but the answer is one which is in the end more likely to be provided by the dependent peoples themselves than by us. I confine myself here to matters which we cannot doubt to be within our grasp, given a due attention to careful planning and systematic execution. Let me put them in more definite terms. We must see that they have that type of nutrition which will establish the necessary measure of resistance to disease. We must secure for them a subsistence adequate to provide the strength necessary for sustained effort in cultivation or industry. They must have access to medical facilities for dealing with physical disorders, epidemic or otherwise ; and access to such measure of popular instruction as will enable

the mass of people to adjust themselves to the need for new economic and cultural conditions. These are fundamentals, and precondition all further social progress.

But planning, even at this early stage, cannot halt there. We interpret economics to-day in terms of welfare, not of wealth, but it is a condition of welfare that the government should itself have the means of raising finance for capital works or for the provision of social services, and that the population should be furnished with the means of acquiring articles which a non-industrialised country must necessarily import. All the exportable assets of the territory, whether in the form of metals or of exportable crops, must therefore be turned to the best account. But this must at the same time be effected on terms which will avoid prejudice to the primary claims of subsistence production or undue disturbance to a social economy not yet adjusted to the needs of industrial life.

I started by propounding the general question, how far had we actually availed ourselves of the opportunities we then possessed of planning the development of our more recently added territories? I can now ask, more specifically, how far have we planned scientifically for development on the lines which I have just described? For I take it that the use of science in colonial development means just this, that we start by surveying the whole field in order to get the problems which it presents into proper alignment, and afterwards proceed systematically to their solution, using the most expert agencies available for advice as to the methods to be employed, and expending the resources at our command in the order which the relative importance of our problems indicates.

It is doubtless unduly idealistic to suggest that we could ever have proceeded on lines involving so much prevision and systematic procedure as this involves. It is at all events clear that we did not do so. I will not multiply illustrations; but let me select a few. We have in many instances allowed concentration on the cultivation of export crops to outweigh the needs of subsistence production, with results no doubt less disastrous than those which at one time attended the use of the Culture System in the Netherlands East Indies, but sufficiently grave to require legislation compelling a minimum subsistence cultivation, in order to prevent famine. It is only in the last few years that we have inaugurated a general survey of nutritional conditions in the colonies. It required the revelations regarding the ravages of sleeping sickness in the neighbourhood of Lake Victoria during the years 1901–1905, where we owed much to inquiries initiated by the Royal Society, to bring home to our administrations the deplorable health conditions prevailing in many parts of Africa, and there are still many areas in which no general survey of these conditions has yet been made. The extent of popular education was for long dependent on missionary initiative, and the State did not control the curriculum. It is only of very recent years that we have realised the widespread menace of soil erosion and the need for special measures for conserving soil fertility.

Passing to another field there are many territories where geological survey has been very superficial, and the discovery of mineral deposits has been left to the initiative of individual prospectors, who have been primarily interested only in the precious metals. Land survey has in some cases been so exiguous that railways have had to be re-aligned at great cost owing to the lack of accurate maps. Or take yet another field. Native land revenue systems have in Africa still to come under comprehensive survey, though agricultural progress must largely depend on the evolution of a definite and easily recognisable system of land rights. Recruitment of labour for industrial enterprises has not until lately been regulated by any programme based on the capacity of different areas to provide man power without undue social disturbance or interference with subsistence cultivation. It has been left to the management of these enterprises to investigate the most suitable dietary for labour and to apply it at their own discretion.

We must readily admit the obstacles which have stood in the way of a systematic planning of development. No one can justly overlook these, just as no one should underestimate the vast improvement which we have actually made in the life of the dependent peoples, nor the services which the high sense of duty of the administrative staff has rendered to them. Nor must one overlook the many contributions which have been made, especially of late years, by our scientific bodies and the labours of individual scientists. I am dealing merely with the question of method. It is sometimes said that if we have failed to be more systematic in our policy of development, it is because we are not ourselves either a very logical or a scientifically minded people. In our own national life we prefer to act on a sense of expediency rather than on principle; we trust to improvisation rather than to logical scheming, holding that this is more flexible and more readily adjustable to the complexities of actual situations than are the results of more abstract thinking. We admit that the method of trial and error may be costly in material and slow in obtaining results; but we feel that a strict application of logic has often led others into situations from which recovery has been even more costly both in time and effort. But I believe there is a more practical explanation. Our colonial policy has in the past been dominated by certain traditions derived from our own political instincts, and by the conditions in which we originally acquired jurisdiction over our dependent peoples. We saw our first duty in protecting them from exploitation and misrule, and in fitting them to maintain, in a political sense, their own position in the world. That tradition was far from unworthy, but it may be that it unduly diverted our attention from the need of pursuing a constructive policy of improvement in the physical conditions and the standards of life of these people. In the second place, we have in the past tended in our own domestic life to look on the State chiefly as a political organisation, and not as one of which the primary function is the promotion of the social welfare, the health, and the standards of life of its citizens. This generation has seen a radical change in our conception of the functions of the State, and with it has come a new and more constructive outlook

on the activities which should engage the attention of a colonial administration.

This changed conception of the functions of the State has had a marked influence on the attitude of the British public itself towards its colonial obligations. It was in the past usual to make an appeal to a sense of trusteeship, a trusteeship which, in a well-known phrase, ought to be exercised alike in the interests of dependent peoples and those of civilisation at large. But that form of appeal had its limitations. It was capable of a great variety of interpretation, and it supplied no standard for action. It left it open to the public to feel that it could satisfy its sense of obligation by the maintenance of a humane system of administration and by taking a liberal view of the political future of its dependents. The new conception of the State puts our colonial obligation on a concrete plane, and one with which the public is not unfamiliar. It may not feel itself able to distinguish between the value of a system of indirect rule and one of direct rule ; it may not be clear as to the stage at which a dependent people can be entrusted with the political responsibilities of self-government. But it needs little knowledge of the mysteries of administration to realise what it means that a district as large as Yorkshire has only one doctor and two dispensaries, or that two-thirds of a great territory is unable to maintain domestic animals of any kind owing to the prevalence of insect pests which are believed to be removable.

It is the general acceptance of this new conception of the State in relation to the provision of social services which rendered it relatively easy to secure the liberal provision of funds guaranteed by the Colonial Welfare Act passed in 1940. We started at the outset with the feeling that a colony should be self-supporting. We advanced a further stage when the Colonial Development Fund Act of 1929 made it possible to spend up to a million pounds a year on assistance to certain of the social services, or on types of inquiry which the colonies were not able to finance. The Act of 1940, however, is a final recognition that further development cannot be achieved without more far-reaching and more consistent assistance.

It is now the task of the administrator to make a full use, and at the same time a more scientific use, of this position. Let me indicate some of the directions which the more scientific use of the opportunities now presented might profitably take. I will begin with some of our more fundamental needs. In the first place, we need to place our demographic information on a more satisfactory basis. Even the total population of some of our territories is a matter of assumption, and dependable vital statistics are generally unobtainable. More accurate information is required not only for the planning of health services, but for a great variety of administrative purposes, including the regulation of labour recruitment. The extension of land survey is essential, at all events so far as regards geodetic triangulation, in order to provide the network within which cadastral survey can be conducted as it becomes necessary. We must not repeat the experience of South Africa, which paid heavily for its delay in carrying out the scheme of triangulation put forward by Sir David Gill in the seventies of last century. Again, the fuller knowledge of our colonial assets demands an expanded service of geological survey ; the discoveries made by the Government geological staff in the Gold Coast and Sierra Leone show how ample a return the Government revenues can secure for the small outlay involved. To-day much of the energy of our small geological staff is diverted in some areas to the provision of water supplies or the regulation of mining licences. I have referred to the inauguration of a nutrition survey, a movement largely stimulated by the work of Sir John Orr and his colleagues in Kenya, but the specialist staff engaged is relatively small, and in only one or two cases has the survey been associated with the sociological survey which must be an essential part of a study of this nature. It is not enough to know if a dietary is inadequate or ill-balanced ; we must know also the social habit which determines its selection or hinders the use of available substitutes.

As regards health work, I have already pointed out the absence in many territories of a complete survey of health conditions. There have been studies carried out of particular localities which have proved of the highest value, but much has still to be done in this direction. Thus, to take an example from Africa, we know as yet very little about the exact range of the 'dormant' or 'silent' stage of yellow fever, and we should indeed know less but for the aid given by the Rockefeller Foundation. The incidence of tuberculosis is still unexplored, and there is reason to believe that previous assumptions of the incidence of leprosy are largely incorrect. It is essential again that we should have a more precise knowledge of the effects of tropical and particularly equatorial climates, on the physical condition of Europeans. It is equally necessary that we should know whether there are any such fundamental differences in the physical constitution of tropical peoples as will effect the application to them of the European system of curative medicine.

Our work of survey must necessarily include also studies on the social side. One such is that into land tenures, to which I have already referred. Another is the study of the procedure of native marketing, on the improvement of which depends the expansion of the internal economy of the colonies. A third is the investigation of the extent to which indigenous customary law affords a basis for the formulation of a uniform legal system, which will adjust the procedure of European law to the requirements of the more primitive populations.

It is to be hoped that much of this work will become practicable when the special fund for research provided by the Act of 1940 becomes available after the war. The provision which Parliament has thus made for colonial research is in itself significant of the new order of ideas, and I know of no parallel to such a measure in other countries. But survey, though essential to systematic planning, is only part of a scientific approach to colonial development. There still remains the need for research into the wide range of specific problems, arising in the field both of the applied and social sciences, which require local investigation, either because they are

peculiar to colonial conditions or because, though more general in character, they present features which can only be studied within the colonies themselves.

Here I suggest that there are certain guiding considerations. It is advisable that the facilities afforded by our imperial institutions of research should be utilised to the fullest extent, and that the energies of colonial research workers should be strictly limited to problems requiring local inquiry. One is struck by the limitations imposed on the research worker by isolation alike from the assistance and the criticism of professional colleagues. The well-known study into the alleged mental deficiency of Africans made a few years ago at Nairobi would have taken a very different form if it had been made in the more critical atmosphere of a European intellectual centre. Secondly, we should seek to group colonial research workers into suitable centres and to bring their work under some form of professional direction. At present the staffs engaged in research are liable to have their energies diverted to routine work, and when they undertake longer range inquiries the subject is often dictated by their own choice or pressed on them by local interests in a position to influence their services.

There arises a further problem for which I have some difficulty in suggesting a solution. It is possible to envisage group centres for agricultural, medical or similar research, each under its own professional direction. But how are the efforts of these different departments of inquiry to be co-ordinated? Few of the major problems of the colonies can be solved by specialists in one branch of inquiry alone. The problem of subsistence agriculture is not to secure the maximum of food but the maximum of nutrition. The interest of the veterinarian in the protection of cattle from epidemic disease seems actually to compete with that of the specialist in soil conservation, who sees in the increase in the number of cattle the prospect of a progressive denudation of the vegetal cover, and of consequent erosion. The silviculturist demanding an extension of the area of reserved forests in order to conserve water supplies and climatic conditions encounters the specialist in pastures who claims that the best protection is obtainable not from the forest tree, with its high figure of transpiration, but from selected herbage. What agency is there which can exercise joint direction over these different interests in research, or at all events decide the relative importance of their application in practice? That is a question to which the lay administrator would certainly welcome an answer.

Let me add one final consideration. I have purposely refrained from instituting comparisons which might suggest that other colonial powers have given either greater or less attention to scientific planning than we have ourselves. I have therefore made no reference to the extensive study of the economics of production made by the Dutch in their East Indies, or the use made in the French colonies of their metropolitan research institutions, such as the Pasteur Institute, or the scientific approach made by the Belgians to certain aspects of medical work and to the problems of labour supply, or the unusually extensive programme of scientific inquiries with which Italy inaugurated its régime in Ethiopia. But if any lesson would seem likely to emerge from such a comparison it is this. Admitting a certain difference in policy and ideals, there is a very striking resemblance in our concrete problems. That we should seek for every means of co-operation in solving them is so obvious as to be commonplace. But how far does this co-operation extend at present? In one sense, of course, all scientific inquiry is co-operative in so far that its published results are the common possession of all scientists. We have, again, had instances, though not as many as might be expected, of international conferences on scientific subjects which have a bearing on colonial development. But there are not many instances of combined planning for dealing with specific problems in the field of the applied or social sciences. An outstanding instance to the contrary is that of anti-locust research, which has become largely international in character. There are perhaps other instances, but they must be few. Their restricted scope justifies, at all events, the suggestion that a modern world which can combine to control the production of tea or rubber, or tin, or copper, in the interests of an investing public, might well find the means of exhibiting a greater solidarity in dealing with problems lying within the field of the applied sciences which are vital to the welfare of the colonial peoples.

Prof. Alvin Hansen

I SHALL address myself directly to the programmes of research currently in progress in my Government and with special reference to programmes relating to post-war reconstruction. These have to do not only with internal policy in the United States but also with external economic relations.

A number of governmental agencies are at work on various aspects of post-war plans and programmes. The National Resources Planning Board has been entrusted by the President with general responsibility for this work. It has been instructed to serve as a clearing house for long-range studies undertaken in various governmental departments and divisions and in private agencies. It is commissioned to furnish the President and the Congress with information on these matters.

For the last eight years the Planning Board has been engaged in studies relating to the natural, human, scientific and economic resources of the nation. The Board is moreover required by statute to maintain a six-year programme of federal public works. This programme provides a 'shelf' of projects which can be speeded or delayed according to the requirements of the economy.

The Board has made exploratory studies relative to the needs and possibilities of developmental and public improvement projects involving land use, transportation, and water and energy resources. In 1934 the Board sponsored a survey of the extent of soil erosion in the entire nation. A trained force was sent into every county. The result was startling. The immensity of the damage discovered exceeded anything previously realised. This survey led to the establishment of the Federal Soil Conservation Service, with authority to make surveys, conduct research, establish demonstrations, and inform and educate

the public about soil conservation. In 1936 the new Agricultural Adjustment Act combined the dual purposes of soil conservation and adjustment of agricultural production.

The Agricultural Conservation programme is administered locally by county and community committees composed of farmers. There are now 135,000 of these farmer-committee men. They are currently engaged in promoting the food programme under which American farmers are expanding the production of dairy, poultry, meat and other food products for shipment under lend-lease to Britain as well as for the better nutrition of American citizens.

The Soil Conservation Service has embarked on a programme of action on four different fronts : (1) research ; (2) surveys and mapping ; (3) education ; (4) direct assistance to farmers. The first operations of the Service were of a demonstrational nature. Farmers were invited to enter into co-operative agreements with the Service under which the Government furnished plans and technical assistance for a system of farm conservation management.

In 1937 the Service began to concentrate attention on soil conservation districts. Those districts are legal subdivisions of the States. The districts are local entities having authority to enter into agreements with the Department of Agriculture for assistance in carrying out conservation operations. Drainage systems are worked out and rotation plans are applied. In 1936 the Flood Control Act charged the Department of Agriculture with responsibility for watershed treatment.

The Forest Service is responsible for the management of extensive forest land owned by the Federal Government. These forests are managed with a view towards soil conservation. The Forest Service is also responsible for the planting of shelter belts in dust-blown areas.

According to the difficulty of the job and the community importance of the work, private farmers can get labour, equipment or other assistance through the Soil Conservation Service, the C.C.C. or the W.P.A. in carrying out conservation measures.

Land-use planning committees have been set up composed of farmers and of Department of Agriculture representatives in the locality, including the local forester, the county extension agent, the A.A.A. chairman and the Rehabilitation Supervisor of the Farm Security Administration. These land-use committees operate under the Office of Land-Use Co-ordination. These committees are now functioning in about half of the counties. They constitute a forward step in democratic government and contribute greatly to soil conservation.

Nevertheless, the greater part of the job of soil conservation still remains to be done. The launching of a nation-programme is impeded by the scarcity of scientific knowledge. An intensive national research programme is under way, but much remains to be done. Plans are being developed for the post-war emergency period, looking towards the training and employment of large numbers of people in conservation activities in order to achieve the dual goal of relieving unemployment and of protecting the nation's land and agricultural resources. Large projects are needed in erosion control, flood control, drainage and reforestation.

I turn now to the problem of the full use of our water resources. This programme requires large-scale, multiple-purpose projects for whole drainage basins. In the highly mechanised world after the war, water power resources will be more important than ever before. Plans are now under consideration for the conservation and full use of these resources through ' gridiron ' or interconnection of power transmission lines, and greater use of the energy resources from falling water.

One of the most significant achievements of the United States Government during the past ten years has been the redevelopment of the Tennessee Valley [described in an earlier communication by Prof. Luther Gulick]. There are in the United States from ten to twelve great regions drained by river systems (the number depending on certain more or less arbitrary classifications) where some programme similar to the T.V.A. might be applied. Each river system must of course be examined from the point of view of its own special problems. There can be little doubt that some form of regional development of the great river systems of the country should be undertaken after the war is over.

May I now turn briefly to the work of the Rural Electrification Administration. Under the government programme, private enterprise has moved forward splendidly. By now 30 per cent., or about two million farms, are electrified. About three-quarters of the newly-connected farms are served by lines financed by the R.E.A. But we are only on the threshold of a great new development.

Technical assistance is made available by the R.E.A. to farm co-operatives and other borrowers. The aim is to help farmers to perfect their co-operatives and to develop the greatest possible degree of local autonomy. Rural electrification holds out promise of a more balanced economy. It facilitates decentralisation of industry.

My third point relates to the researches of the National Resources Planning Board and other agencies with respect to the need for large-scale rebuilding of our cities. The Federal Reserve Board, in co-operation with the Resources Planning Board, has undertaken a special study of urban redevelopment. The proposals which have emerged from this study have been checked and rechecked with urban planners and housing specialists in and out of the Government. City officials, business leaders, and real estate boards all agree on the need for extensive replanning and rebuilding of cities. The job is so urgent that it must be undertaken just as soon as men and materials become available. It is generally agreed that it can only be done with federal financial assistance.

Aid should be extended in such a manner as to induce the maximum possible investment by private enterprise.

The federal programme should, in my judgment, embrace four main divisions :

(*a*) City planning and land acquisition of slums and blighted areas as the first step in urban redevelopment.

(*b*) Rationalisation of the residential construction industry.
(*c*) Stimulation of the production, by private enterprise, of housing for rent to families of moderate income.
(*d*) Public-subsidised housing for the low income groups.

The slum and blighted area land we believe should be acquired as a by-product of civic sanitation. In its subsequent use the acquisition cost should be ignored. Actual use should conform to the master plan for the entire metropolitan district. The land should be offered for lease on favourable terms to private enterprise, but should be used for public development if unsuitable for private enterprise.

Related to urban redevelopment is the replanning and rebuilding of terminal facilities adapted to modern requirements for interchange among rail, highway and air carriers, and between terminals and markets.

Turning to quite another area of research, plans for expansion and improvement of the social security programmes are under way through the activities of the appropriate operating agencies of the Government. Food and nutrition problems are being explored with an eye on the post-defence period as well as on defence.

In recent years the Department of Agriculture, starting from the effort to relieve farm surpluses, is increasingly attacking the problem of malnutrition. In 1934 surplus farm products were purchased by the Federal Government for distribution to needy families and for use in school lunch programmes. In 1939 the Food Stamp Plan was inaugurated. This plan is now reaching about four million people and distributing foods worth $120,000,000 per year. Most of these foods are the protective foods needed by undernourished families. The free lunch programme is now reaching about four million school children. Low-cost milk is being distributed in several of our large cities.

On May 27 of this year a National Nutrition Conference for Defence was held in Washington. The Conference recommended vigorous and continual research in nutritional problems ; more widespread education of doctors, dentists, social service workers and teachers in the newer knowledge of nutrition ; the mobilisation of motion pictures, the radio, the press, home and community demonstrations to spread knowledge of nutrition among the people. The farm surplus problem for many products could be wiped out if our whole people were properly nourished.

The programme of nutrition should, however, be attacked on an international basis. An International Food Stamp Plan has been suggested. Arrangements could be made for international exchange of surplus products to be used for free school lunches. The means exist for the first time in history to produce abundant food for all mankind. The problem cannot be solved without international co-operation.

The general level of health to-day is higher in the United States than ever before, but it is none the less true that large sections of the people do not share in this general high health level. And it is just beginning to be realised that it is a basic public concern to insure available treatment for all.

The existing services are far from adequate. In 1934 President Roosevelt appointed a Committee on Economic Security to study, among other things, the country's health needs. After the passage of the Social Security Act in 1935, he appointed the Interdepartmental Committee to co-ordinate Health and Welfare Activities. The findings and recommendations of this Committee, made known in 1938–1939, indicate the long distance to be travelled before we can say we have an adequate public health programme.

The Committee envisaged a gradually expanding programme, reaching its peak by the end of the tenth year. The programme recommended involves the expansion of the general public health services ; public health organisation and facilities for combating special diseases, maternal and child health services ; expansion of present hospital facilities and medical care for the medically needy.

Finally a word about research in international economic relations. Research in the physical and biological sciences must help win the war. But it is peculiarly research in the area to which I have just referred that must help win an enduring peace. To begin with, we must recognise that no enduring peace can be founded on an economy suffering from violent economic fluctuations. If we muddle through another decade of economic frustration and mass unemployment, we can only expect social disintegration and another international conflagration.

A positive programme of post-war economic expansion and full employment, boldly conceived and vigorously pursued, is imperative. If we are to lead the world out of chaos and insecurity we must first and foremost offer our people opportunity, employment, and a rising standard of living.

Economists have hitherto far too complacently accepted the trade cycle as an inescapable characteristic of a system of free enterprise and private property. But we are now beginning to realise that the very survival of free enterprise demands that we solve the problem of depression. Moreover, the problems of international economic collaboration can be mastered only on the basis of substantially full employment in each of the great industrial nations.

In my country, our great Secretary of State, Cordell Hull, has thrown his influence into the programme of promoting world-wide trade on the basis of non-discriminatory trade practices and equality of trade treatment for all nations. With strong tenacity of purpose and frequently against great odds he has stood out against narrow regional preferential arrangements. He believes, and I think rightly, that we must work to achieve world-wide prosperity and world-wide trade on a multilateral basis. In my country we are more and more realising how important for this programme is a high level of business activity in the United States. We have learned in recent years that as production rises to high levels in the United States, there follows therefrom a perfectly enormous increase in imports of the raw materials needed to feed our great expanding industries. Under these circumstances our imports of raw

materials from Canada, from Latin America, from the Far East, rise to very high levels, and moreover with high internal prosperity our imports of luxury products from Europe and American tourist travel abroad greatly increase. Thus the internal prosperity in the United States distributes purchasing power throughout the whole world, and promotes world-wide prosperity.

All this has a very special meaning for Britain. We are all aware that Britain will in the post-war world be confronted with a special problem with respect to her international balance of payments. Her merchandise exports must rise greatly, perhaps double, in order to obtain adequate exchange to pay for her necessary imports. She cannot export to a depressed world.

It is my firm conviction that internal prosperity in my country could be very much promoted by economic collaboration between Britain and the United States—collaboration to pursue parallel and co-ordinated policies of internal expansion. It is further my conviction that world prosperity and world trade presuppose a revival of international investment. Large developmental projects—railroads, public utilities, airways—must be undertaken in China, in other parts of the Orient, in Latin America and in eastern Europe. This can be done by private capital eagerly awaiting opportunities for profitable investment. Under existing conditions, however, private capital will not enter the foreign field unless safeguarded by a government insurance corporation. In the field of housing in the United States we have induced an abundant flow of private capital in residential construction through the insurance of mortgage funds by a governmental corporation. Something of this sort must be implemented to release private funds for foreign investment.

After much thought on this problem, it is my firm conviction that such a programme could be placed on a sounder basis and command the widest confidence throughout the world if it had the co-operation and support of the Governments of the United States and of Great Britain. Moreover, collaboration along these lines, aiming at world-wide expansion, world prosperity and multilateral world trade, would do much to promote mutual understanding throughout the world. It is upon this basis of understanding and collaboration that we must build a new and a better world ; a world of freedom and opportunity for the peoples of all countries. The policy of narrow, selfish, restricted and preferential arrangements must be firmly put aside. The keynote for the future world which we hope to build must be world-wide expansion and equality of opportunity for all nations.

Prof. P. Sargant Florence
The Distribution of Industry and the Population

EXCEPT for the idle rich and those retired, adult persons must live where they work. Hence the distribution of the population corresponds to the distribution of industry. Which is cause and which effect depends on the type of industry. Some industries, such as the extractive, must take place where the natural resources of soil and minerals exist ; here population follows the industry. Other industries, such as the ' residentiary ' services, must be distributed where people require serving. Here trade follows the population. The location of yet other industries, particularly manufacturers, are partly determined by sources of labour, partly by natural resources. It is these ' foot-loose ' mobile industries that give greatest scope for planning, for their population is not narrowly circumscribed by man's needs or by nature.

The category into which any particular industry falls can be determined by the help of the factor of location of the industry in any one area and by its coefficient of localisation for the country as a whole. These measures are based on the deviation of the local distribution of the industry from that of the occupied population in general. Low deviations indicate residentiary industries ; high deviations without correlation to relevant natural resources, foot-loose industries.

In planning the foot-loose industries the economic criteria of maximum present or future return at minimum cost are important, but not necessarily final. There are socio-economic, ' distributive,' criteria to be considered of stability of employment between periods and of equality between persons. And there are the purely social criteria of health and of a fuller life and opportunity for all.

Free play given to economic forces in the past has led to localisation of a single industry in one district. This has resulted in derelict areas and ' ghost towns ' when that industry is depressed or declines altogether. Diversification of industry may be adopted as a policy to ensure that every community has a balance of occupations between men and women, between seasons, and between fluctuating and stable, and declining and growing industries.

Economic freedom has also led to concentration of all sorts of industries in one metropolis or conurbation—a ' great wen ' like London. Dispersion of industry is a policy to ensure the blending of town and country amenities and outlook.

Recent scientific progress has on the whole intensified the economic trend toward industrial concentration. With fuel and material economy there need be less scatter of factories over the coal or mineral fields, since proximity to raw fuel and materials is less important. Moreover, steam-generated electrical power is cheaper in concentrated cities where transmission costs are low. Again, telephoning, unlike older-fashioned telegraphing and posts, is cheaper for shorter distances. For all these reasons costs have been reduced to manufacturers located in proximity to one another. Even the growth of the road transport favours the large cities, since a haulier can find a return load there but not in the country.

If the social and socio-economic criteria are accepted and dispersion adopted as a policy much hard thinking and fighting lies ahead for planners. A policy that is an obvious ' stratagem ' during the war, may not be so obvious an economy for peace times. Will, for instance, the encouragement of agriculture be continued after the war and the population thus dispersed from manufacturing into agricultural areas ? The answer partly depends on international considerations of special interest to this meeting. If tariffs or

quotas on manufactured goods are persisted in by the larger, especially creditor, nations, there can be little national specialisation in manufactured exports, and England can no longer be the workshop of the world. She must try to become self-supporting and dispersion into agriculture will be a necessity.

In any case, whether plans for dispersion are internationally forced, or free, the government will have to implement plans by pressure on private enterprise. In a democratic state this presents difficulties. Encouragement by financial inducements may prove too expensive and at least a negative compulsion may have to be resorted to by refusal of licence to factories to settle in certain congested areas such as London.

Prof. G. Findlay Shirras

I SHOULD like to refer very briefly to the aspect of population presented in India and in Asia generally. I have served the Crown in India for thirty years and have been very much impressed by the appalling rate at which the population is growing in Asia. To-day India is the most populous country in the world, China not excepted. In the Dutch East Indies the population is increasing at an enormous pace and the same has to be said about Japan. While the growth of population is going on at an increasingly great rate in those countries what is happening in Europe is just the reverse. The whole of north-west Europe will gradually die out if the present state of things continues. With the exception of the Netherlands the people in the countries of north-west Europe are not reproducing themselves. In order to maintain our population in this country we ought to have 100 workers producing 100 daughters who in turn would become mothers of 100 daughters ; but actually we have only 76. What is going to happen ? Is there not need for planning in the West ? With the population increasing so rapidly the East is turning to industry and turning out goods at prices with which the West cannot compete.

There is a gap between the economic East and the economic West, and I believe that by planning we can do a very great deal to fill it. To-day India is in the war and is producing a great deal of war material. In India there are some of the finest cotton mills in the world, and iron and steel is being produced there at a great rate. Japan can produce a pair of tennis shoes and sell them in Tanganyika at half or one-third of the price of British-made shoes. Those are problems we must deal with after the war.

Another problem arises because of the disproportionate numbers of men and women in the population. There is a scarcity of women in the Dominions overseas. In this country the position is reversed. Why cannot we plan population in the same way as we can plan the supply of goods ? I will not say that marriage is merely a matter of putting people together at an opportune time, but we should try and plan so that people can go overseas in a way that is not possible at present. In the United States, in Canada, Australia, and South Africa there are fewer women than men. This question of population should be tackled in a very serious way after the war, not by administrators alone but by scientists and by governments.

Prof. Dr. J. Métadier
Proposed Creation of an International Society for Scientific Research

IN the scientific organisation of the world, which, after the war, will be as necessary to civilisation as is to-day the destruction of the Panzer divisions, the planning of scientific activities will have to be given special attention. Discovery being the principal aim of science, it will be necessary to guard against research being hampered by technical applications. This will not be easy owing to the appeal of technical callings which provide a better living than pure science. It will be necessary to encourage the pioneers of science and the theorists who guide them. ' Those madmen,' as Ernst Mach so aptly said, ' save other men the trouble of thinking.'

It would seem that there will be no need to fear a scarcity of scientific research workers. The opportunities due to the progress of science and its innumerable ramifications continue to develop in geometrical progression. On the other hand, scientific research gives indeed unspeakable pleasures to the soul, but is not as generous with the *nourritures terrestres*. The young scientist needs a strong passion to remain true to his profession. What is to be done ?

One can certainly improve things by further developing team-work, which makes it possible to use to the utmost the less gifted workers ; but this is evidently not sufficient. Now the idea presents itself to ask the State to ensure a decent living for all those scientific workers working in the interest of the community. But it is not quite clear how this could be done to avoid any abuse or without forgetting anybody. In fact, this system of scientist civil-servants is already being applied, with this difference—that the scientists, with a few exceptions, are not paid for their research work, but in another capacity, that of teaching in general.

There is here an anomaly calling for closer consideration, as it puts us on the way to the solution. The case of the scientist who is remunerated in another capacity in addition to his principal calling which is that of ' discoverer ' is unique. The writer, the musician, the sculptor, the painter sell their productions ; the actor, his talent ; the scientist alone does not sell the result of his labour. This fact, abnormal when one thinks about it, emanates perhaps from a habit—the first modern scientists, those of the 16th, 17th and 18th centuries, cultivated science and philosophy as a recreation. They often belonged to a social class who considered it below their dignity to work for their living. Hence perhaps the conception that the remuneration of scientific labour was incompatible with the dignity of the scientist.

In my opinion, it must be admitted, as a principle, that scientists, like all other human beings, ought to be able to live by their profession, and even to live comfortably. How can this be done ?

Let us see how others do it. It appears at once that very few producers deal directly with the consumers. The great majority avail themselves of the services of intermediaries.

The scientists could in the same way exploit their labours through the intermediary of a kind

of co-operative society, an International Society for Scientific Research. This society would have for its principal object the management of a fund for scientific workers. This fund would have to be maintained by payments made from the profits realised in the industrial and commercial exploitation of scientific discoveries. The society would have to investigate the scientific bases used for each industrial process or each product commercially exploited, whether patented or not.

Every process or product exploited, which is the result of a scientific work, published less than say fifty years ago, would entitle the society to levy a small percentage which would not in any way interfere with the commercial exploitation thereof. This percentage would be similar to the copyright of authors and musicians, with this difference, that the scientific royalties would not be levied by the author, but by the International Society for Scientific Research. This procedure would avoid the difficulties which would be encountered in the quest for the authors, and moreover, it would have the advantage of safeguarding the ' dignity ' of the scientist.

The society would make use of the funds thus obtained for prizes, pensions and research scholarships.

(1) The prizes would every year be conferred upon those whose work, when exploited, would carry royalties paid into the funds of the society. Generally the prize would be in proportion, as far as possible, to the sums received by the society for the works of the author entitled to the prize. Due note should be taken that these prizes would not consist of a single payment but of yearly payments. These would last just as long as the society received the corresponding royalties—that is, during the author's life, and even fifty years after his death. Summing up, the author would not receive any royalties, but prizes. The society would itself distribute the prizes in the best way for each and everyone concerned. The beneficiaries would, in this manner, enjoy what Gide called *le superflu si nécessaire.*

(2) Another part of the funds at the disposal of the society would be used for pensions for those workers who had reached a certain age and who would not be receiving any prizes. Thus, men of science would enjoy that freedom from want which is spoken of in the Atlantic Charter.

(3) A third part of these funds would be used for research scholarships for those workers not entitled either to pensions or prizes.

In order to enjoy these advantages, one would have of course to be a member of the society, and for this, it would be necessary to supply proof that scientific research constituted one's principal occupation. The admission to membership would have to be renewed each year on the basis of documents relating to the researches carried out during the year, or those still to be made. No official distinction or degree would be required.

It is, of course, impossible to go here into the details of the exact working of such an undertaking. It is at once clear that it would have to be on an international basis. If this were not the case, the royalties collected, even if small, would handicap the industry of the country which would apply this system without other countries doing the same.

The prizes paid out by the society should never be such as to incite the students of science to apply themselves only to the study of certain subjects in preference to others, and in this way to threaten scientific research as a whole, and disturb its natural course.

Finally the proposed society might also supervise the international organisation of scientific research with a view to attaining greater efficiency.

M. M. Wynants
Belgian Commission for the Study of Post-war Problems

In many people's minds the problem of town planning is still vague, which accounts for the word being often misconstrued. Few understand the real aim of the problem. Its scope is usually limited, it is often taken to connote petty details or even architecture. Such is not the case. We cannot study effects without their causes. We must go back to the origins of town planning. We must not overlook that which gave birth to it, namely, society. Any form of society, at any period, is always the result of a preceding form of social organisation combined with new attainments that are factors of evolution. Both of these shape a society into its own character. Besides, material needs will dictate constant rules in agriculture, in industry, and in commerce.

These three notions are essential to the understanding of the most important problem of demography—that is, the distribution of men in areas that will provide them with a living, and their differentiation in groups of varying species and sizes. Between these groups occur exchange and relations of all kinds which give birth to means of communication by land, by water and by air. This process gives us the essential elements of town planning.

Town planning is a means created by a society working to reach its aim. It is the very expression of the organisation and the possibilities of a collective body. On the one hand town planning corresponds to the aim of society and to its means of reaching it. On the other hand its fate is also bound up with general economy.

Like town planning, general economy consists, to begin with, of census and control of surroundings favourable to man—that is to say, classifying and fixing the limits of areas according to their products, industry, agriculture and so on. Social purposes, hygiene and other considerations are more factors that guide us in determining the creation of inhabited and industrial zones and the distribution of individuals in groups varying in character and in size according to their occupations. Such is quite clearly the highest point reached by town planning, its lowest point coinciding with architecture. This differentiation appears in the progression : architecture, land utilisation, planning, in which progression the middle term is an activity common to the higher and to the lower point.

The various questions to which planning of post-war reconstruction gives rise are : the political organisation of a country, international politics, economic relations, social relations and material reconstruction. These are the different aspects of the problem, each of which should be examined separately. Yet they are but aspects

of one and the same reality. With the progress of civilisation, these different spheres of life in an organised community have become more closely interdependent. It is impossible to propose a solution in one or the other of these fields without automatically causing corresponding reactions in the others.

The conditions of a country's existence, however, both in the political and in the economic sphere, depend in a very large measure on the conditions prevailing outside its boundaries, and no solution could adequately serve its interests that does not take into account its position within the international order. We are convinced that the sectional interests of the different nations, whether these be small or great, must coincide in the long run, as all the nations have a major interest in the existence of orderly international relations which alone can guarantee the maintenance of peace and of economic prosperity and social security. A distinction must be drawn between the two fundamental aspects of the post-war problems. The creation of a new peace-time order involves problems that call for a solution on the lines of a permanent and lasting organisation; but, before we come to these, others of a transitory nature will arise instantly on the cessation of hostilities.

Such a distinction between the two aspects of the tasks cannot be dispensed with for the good reason that each calls for a different solution—different as regards the scope, the urgency and the duration of the measures required. It is, nevertheless, evident that the solution adopted in respect of the one set of problems must affect that devised for the other set and that any schemes for dealing with the requirements of the immediate post-war period must be on the lines of the permanent organisation aimed at so as not to prejudice but rather to prepare and promote the lasting organisation.

The very first step will have to consist in supplying food without delay.

Next, there will be an almost equally urgent need for securing the importation of raw materials required for the resumption of work.

The organisation of the transport and distribution of these foodstuffs and raw materials will involve problems relating to transport by sea and available shipping space, on the one hand, and to re-establishment of communications by land on the other.

The problems involved in the financing of these transfers must forthwith be tackled or, at all events, such steps must be taken as to ensure that financial difficulties will at no time delay operations. Problems of such magnitude cannot be solved satisfactorily except by concerted international action.

A number of tasks in the economic field cannot be satisfactorily accomplished except by bodies representing the entire world, or in accordance with regulations of universal scope, or by virtue of general treaties. This applies more particularly to the following problems:

(1) Access to raw materials.

(2) Building up backward areas and creating new markets and understandings as to the production and distribution of staple goods commanding an international market.

(3) A common standard of value.

(4) The prevention of excessive fluctuations in the prices of certain basic products.

(5) Extensive public works of an international order.

(6) Co-ordination of international traffic.

(7) Human migration.

It would nevertheless appear that all these measures, however desirable and necessary they may be, will not prove sufficient. The disorder, the devastation, the loss of balance caused by the war will make it imperative to take more drastic action. On the other hand, economic reconstruction will require far more than measures of a predominantly negative order. Orderly economic relations cannot, however, be maintained if they are not founded on a corresponding organisation of political relations. Nothing could be more important, for the small states even more so than for the great, than the problem of international security. The main problems of post-war reconstruction cannot be adequately solved except within the framework of a thorough reorganisation of international relations, both in the political and in the economic spheres. Social relations are of at least equal importance with economic relations, and their reorganisation is quite as imperative. There is, on the one hand, no social security without political security and economic prosperity. Economic progress and peace conditions must, on the other hand, be so organised as to ensure social stability and security. Both the individual and the family must be guaranteed work and a decent standard of living, irrespective of the trend of business cycles.

The conclusions arrived at as regards the reorganisation of international relations will oblige us to adapt our national institutions to new needs. Thus the whole problem of State Reform is brought up for discussion.

To complete this general survey of the tasks ahead, we must come back to the problem of material reconstruction. This task cannot be accomplished unless by national and international planning. Such planning can and must be but one chapter of the general political and social planning on a national scale, which, again, in some of its main chapters, must take into account the attitude adopted by other states and, in particular, the solution adopted in the international sphere.

Mr. D. P. Riley

The World Planning of Scientific Research

It must be stressed at the outset that any plans for a post-war world, any plans for technological advance after the war, are completely conditional on the outcome of the present struggle against Fascism. Without that realisation, and without the deepest determination to use our skill and brains as scientists to help win that struggle, any such discussions are sterile. Hence it is apposite to discuss first the world planning of scientific research as related to the winning of the war. At the moment there are a number of international scientific commissions at work in an official way. Their operations should be extended, and, I would suggest, the broad outlines

of their decisions made available to the rank-and-file scientific worker. If the junior scientist is expected merely to confine his attention to some narrow specialised problem, and to have little idea of the importance of his work in relation to a co-ordinated plan, he is apt to feel discouraged and go stale. It must be remembered that there is an enormous amount of hack work to be done in every field of scientific research, and it is largely the younger scientists who do it. Also research on war problems is, intrinsically, far less interesting and absorbing scientifically than the fundamental researches carried on, for instance, in peace-time, in university laboratories and research institutions.

I am entering a plea before this distinguished audience for more democracy in science. There should be a place for younger scientists in the councils of scientific planning in the laboratories and factories themselves, and on national and international committees or commissions. I consider that such a step is amply justified by the following reasons. Young scientists, by virtue of their youth, are endowed with energy, initiative and enthusiasm. They bring a new point of view, that of the younger generation, to bear. Their scientific training has been based, not on the conceptions of 19th-century mechanistic physics but on 20th-century dialectical theories, in which the interrelation of the various sciences is continually emphasised. Nowadays a chemist must also be a physicist, and a physicist an engineer, and we younger scientists have been trained from the outset in full knowledge of the diverse and powerful modes of attack on any scientific problem. The need for startling ingenuity, for completely new methods, and above all for quick thinking, is very necessary in wartime. More important than all these considerations, I feel, is the fact that the humbler scientific workers can put forward the viewpoint of the man actually on the job, actually at the laboratory bench, actually at the production point of scientific discovery. They can suggest in planning committees short-cuts which can only be thought of by such people.

The wisdom and conservatism of age and experience could thus be tempered with the effervescence and radicalism of youth. I am quite sure that any tendency on our part to sublime over-confidence would soon be gently and firmly dealt with by our more experienced colleagues. But give us our chance to help, and not only always at the bottom, but sometimes, dare I say it, almost at the top?

Let us as an essential supplement to present official plans put into direct contact with each other rank-and-file scientists in similar fields of science but working in different countries. Let personal contact be established as widely as possible. It would also serve as a valuable basis for international understanding on the cultural level after the war. To this end I consider Lord Samuel's suggestion of yesterday that there should be scientific attachés to our embassies as admirable, and I am encouraged that a distinguished statesman made the suggestion. Could not this be considered with some urgency by the Foreign Office?

Concerning the peace-time planning of research, it cannot be too often stressed that international co-operation is its very life-blood. The Nazis are now learning that to their cost. Science soon deteriorates if subordinated for years to their war-machine and aggressive aims. I would suggest in peace-time a greatly increased exchange of younger scientists between the nations. It is not sufficient to rely on private philanthropy to achieve this, as is largely the case at present, but State funds should be made generously available. As I envisage it, these men and women would give to the foreign laboratories in which they would work the different outlook of their home training. They would bring with them different aspects of technique and approach. They would, conversely, learn and take back home with them an understanding of the methods used abroad. All this should occur during the formative years of their lives. Parochialism in science does exist and must be combated; this is one way of doing so.

The nature of modern science demands not only planning and team-work, but international planning and team-work. The international exchange of ideas is essential. One task we might with advantage immediately take up is the overcoming of the language difficulty between this country and the U.S.A. on the one hand, and the U.S.S.R. on the other. This could partly be done by a co-ordinated system of abstracting of scientific papers on both sides. In my own University of Oxford it is compulsory on students of chemistry to learn German. This is obviously a reflection of the days when German chemistry was a leading force in free science. Surely nowadays, and more so after the war, it is at least as important for English-speaking scientists to learn Russian as German?

In my own field, for instance, a start was made some years ago to parcel out the work on the world scale, in a general sense, in an attempt to avoid duplication of effort. Partly as a result of this, crystallography is a relatively well-ordered science, and although it is a subject where duplication could be very frequent, it now occurs only in minor and useful ways. More frequent international conferences should be held, and their conception should be different. They should not be held merely to exchange papers and meet fellow scientists, but they should sketch out as far as possible future work. They could so easily, with a modified organisation of conference procedure, become valuable world-planning commissions in their subjects. The improved air-travel routes which will undoubtedly operate after the war will facilitate the holding of such conferences, and difficulties of distance can to some extent be overcome by the use of radio-communication and of disc recordings, as this conference shows.

Exceptional circumstances have helped to bring to this meeting scientists from a great number of countries. It is a truly historic occasion. It would be a great pity if it were looked upon simply as a thing in itself and left at that. Something more permanent must surely come out of it. Let us seize this unique opportunity of getting together and settling some organisational points concerning the international planning of research.

Mr. Hugh P. Vowles, M.I.Mech.E.
Giant Power and World Planning

MASS production and consumption of the necessaries of life should be given first consideration (apart from crushing fascism) in planning a world order. But mass production in the modern world is inseparably bound up with the extent to which the giant forces of nature are harnessed, and placed at the disposal of the workers of the world. The scientific planning of power resources, which now implies large-scale electrification of industry, is the indispensable basis of mass production. The planning of world power resources must accordingly be regarded as of fundamental importance in building the post-war world.

I would like, however, to stress another consideration. There is a well-known saying that faith without works is dead. Another saying, less well known, is to the effect that philosophers have hitherto merely discussed the world, whereas the problem is to change it. Similarly I would say that planning which is not translated into practice is dead, and cannot be regarded as scientific. In my own department of power engineering one might fill a cemetery with plans that were stillborn. The Russians, however, have got well away with such schemes as that for developing the Volga for power supply, transport, irrigation, water service and conservation of river fisheries. Twenty-eight years ago Sir William Ramsay proposed that gas should be extracted from coal in the mines, saving labour and expense. Capital had no use for such a proposal, but in the Soviet Union underground gasification of coal is being carried out successfully on an industrial scale. Yesterday Sir Harold Hartley suggested that steam conveyed to consumers through pipe networks would be a desirable post-war development. But our Allies long ago took this development in the stride of their scientific planning, so that now most large Soviet cities have their pipe networks conveying hot water or steam to domestic, municipal, and industrial consumers; thereby enormously increasing the thermal efficiency of power stations supplying the heat—heat which is normally wasted in other countries.

The diversion of man from his proper task of conquering nature, to the barbarian's aim of dominating others, has been encouraged by basing industrial development on private ownership of the means of production, combined with exploitation of the many for the private profit of the few. In my own sphere illustrations could readily be given from the electrical industry of Great Britain; but the trend of development is more clearly seen in the United States, the country which leads the world in *per capita* output of electricity. The following is an extract from a book (*Technological Trends and the National Policy*) written by a group of American specialists, and presented in 1937 to President Roosevelt by the National Resources Committee: 'The basic determinants of the presence or absence of impediments to technological change lie in the nature of the social, and primarily the economic structure of society, in the degree to which it offers incentives to the masses of the population, and in the manner in which these can be realised through a planned economy. Capitalism has, inherent in its structure and functioning, factors which militate against such realisation, and thus prevent industrial practice from keeping apace with scientific knowledge.' On the other hand, these experts affirm that 'in the Soviet Union technological progress is being fostered as a means of achieving the governmental objective of a socialist large-scale economy for the satisfaction of expanding consumer's needs.'

It so happens that I have made a study of Soviet electrification. Time will not allow me to discuss this subject in any detail, but the following comments may be of interest. In advanced capitalist countries the processes of production have been extensively socialised, but the means of production have remained private property, with the result that the owners secure the lion's share of the benefits which accrue. In the Soviet Union the socialisation of industry has been carried to its logical conclusion, the means as well as the processes of production having been socialised. This has made it possible for industrial practice to keep apace with scientific knowledge. Electrification is planned scientifically and comprehensively on a scale far surpassing anything attempted elsewhere. It is true that now and then notable steps have been taken in capitalist countries on behalf of the public welfare, such as the Tennessee Valley experiment, the Hydro-electric Commission of Ontario, and our own electric 'grid.' But there is no comprehensive and co-ordinated development of power and associated resources. One authority may possibly plan electrification, and another gas supply, but neither pauses to see whether electrification as planned by the one will fit in with gas supply as planned by the other; or that either will fit in with other associated activities. In the Soviet Union, however, co-ordinated and comprehensive planning covers all aspects of the exploitation of power and material resources, such planning forming an integral part of plans covering the whole national economy. At the same time the public welfare is kept steadily in view. The result is unparalleled progress in harnessing the forces of nature in the service of man.

M. le Capitaine H. Bernard

SOME years ago, I complained about an old architect. The buildings he erected were ugly and inconvenient, and their cost was high. The man to whom I made the complaint, and for whose judgment I have the greatest admiration, agreed with all my criticisms, but he added that there was a great and decisive point in favour of this architect: never in thirty years had one of his buildings collapsed. At the time I felt the answer unsatisfactory, but recent events have brought the lesson home.

Scientists (and by this word I do not mean only those whose profession is to promote science but all those who have the habits of correct and precise reasoning acquired in the study of science), it is your duty, both in corporate bodies and as individual citizens, to see to it that the planning for a better world begins where it ought to, that is, in making sure to build on a sound ground. Make sure that the constructions, as beautiful as they may be, do not run the risk of being shattered

and destroyed by a new war. You have your word to say in the problem of eradicating the risk of war.

Professor Hill said yesterday: 'Science is a tool.' It is a wonderful tool. It is also a terrific tool, if misused. Because there are no ethics in science, the ethics must be in the souls of those who handle it. More than 350 years ago Montaigne wrote: 'Science sans conscience n'est que ruine de l'âme.'

Do not let science remain in the reach of those who have repeatedly proved their ferocious instincts. Do with science what is done with the driving licence, remove it from unworthy hands.

The second greatest evil which must be eradicated from the world to come is probably widespread unemployment. Consequences of unemployment are not only individual hardships but also the formation of a medium eminently suitable to the dastardly outgrowth and prolification of Nazism or its substitutes. And this again means war. It is not enough to provide the unemployed with a dole. Even when science shall have achieved the result of drastically reducing the requirements for man power, it will be necessary to leave open to all, at all times, the possibility of earning their living. Economic crises are the major source of widespread unemployment. Scientists have means of helping to prevent such crises. As pointed out by Professor Bernal, methods of statistical analysis and sampling, giving practically instantaneous information, have been devised. Such methods, applied to the study of production capacity, requirements, investments, etc., can provide, without undue lag of time, a sufficiently accurate knowledge of the general situation and trend. It will thus be possible to supplement or correct the automatic reactions of economic factors.

Widespread unemployment has often been ascribed to technological achievements, and science has been abused for its share in such achievements. The community is thus confronted by the following dilemma: to accept the disturbances resulting from progress, or to give up progress. A way out must be found. On scientists rests the responsibility of keeping progress under constant survey and of foreseeing technological developments so that steps may be taken in time to prevent detrimental social repercussions.

There are many other ways of approach to the problem of unemployment, which by no means preclude those just described. I would like to mention one of them. A private firm has to bear at all times the burden of its capital charges, but is allowed to dismiss workers practically without notice when a slump occurs. Would it not be worth while to study the feasibility of imposing on the firm the effective responsibility of at least the partial upkeep of its staff? If feasible, this would probably introduce into the economic system a very important stabilising factor. I have neither the qualifications nor the time to answer such a question, but its importance ought not to be minimised.

I have tried to stress the important part science and the scientific attitude have to play in eliminating the major evils of our times, war and unemployment. The task is not easy. It requires patience and faith.

Before concluding, it is my privilege, as delegate of General de Gaulle, President of the French National Committee, to convey to the prominent men of science attending this meeting the salute of their French colleagues. We know for certain that, under the ruthless Nazi rule, be it direct or indirect, their spirit of resistance remains indomitable. They await eagerly the time when recovered freedom will allow them to carry on their work for the greatest benefit of mankind. May I also ask his Excellency, Mr. Maisky, to express to the Russian scientists the admiration of my fellow-countrymen for their splendid achievements and inspiring courage.

Mr. Maurice Dobb

RECENT decades have shown that, with our present economic order, while science develops the productive powers of human labour, the difficulties of harnessing and utilising those productive powers simultaneously increase. It is a fact that has not, perhaps, received the notice it deserves that the two decades between wars witnessed changes in industrial technique which in certain directions amounted to a major technical revolution. In the period between 1924 and 1935 it has been estimated that physical output per operative in factory industry in this country increased by as much as 34 per cent., while in engineering alone it increased by 57 per cent. in the short period of 1930–1935.[1] Yet what is so remarkable is that this was also a period when under-capacity working assumed unparalleled dimensions—a period when men without jobs and silent machinery became a major problem of the age. It is an ironic commentary on our present economic order that a solution for this cancer of excess-capacity was only found in war or in fevered preparations for war: that the only country outside the U.S.S.R. which came near to solving it in the decade of the '30's was the country which earliest and most ruthlessly organised itself for aggression.

I suggest that most of the traditional precepts of economists are going to be of little use in finding a solution of these problems in the future. The advice given by economists on practical affairs has not always been happy in the past twenty years. True, economists were guiltless of the baser follies of the Treaty of Versailles, and at least one acquired deserved renown by denouncing them. But it was economists—if not all, at least authoritative spokesmen among them—who advocated economy and deflation in the early '20's, which aggravated so disastrously the post-war slump. Economists have stressed the virtues of Treasury Control (even if some of them dissented from 'the Treasury view') and the necessary supremacy of finance over production in a world in which the logic of events was beginning to discard this concept. Economists were most vocal in preaching a neo-Malthusianism and the dangers of over-population in an age which was to prove the threshold of declining population in most countries of Europe. A former President of the Economic Section of the British Association in the middle '30's urged the need to restrain the march of technical progress and to tax innovation

[1] Cf. Memorandum No. 75 of London and Cambridge Economic Service.

in the interest of the values of capital invested in older methods of production. During at any rate the first year and a half of the present war economists have devoted much more time and ink to preaching the need for restricting consumption than they have to the more difficult problems of efficiently organising war-production ; and I do not think that economists have been readier than other men to examine the possibilities of economic planning in a positive and constructive way (in part, perhaps, because of the very meagre financing of research in the social sciences). But there is one misconception current among laymen towards the removal of which I think economists (though again not all of them) can claim to have something to contribute. I refer to the widespread belief that one of the virtues of our present economic order, which should make one sceptical of the claims of the planning enthusiast, lies in the energising force of competition and the profit-motive. Here it needs to be emphasised that competition to-day is something very remote from that which Adam Smith or Bastiat or John Stuart Mill extolled. It has very largely become what economists call monopolistic competition. In the majority of cases it is no longer the instrument through which Adam Smith's ' unseen hand ' of public interest subordinated private interest (if indeed it ever was). Rather is it an instrument through which the public interest is thwarted and the consumer cajoled or bullied. When we speak about economic planning it is this state of affairs that we have to treat as the planless alternative.

If you ask me of what the potentialities of planning consist, I can only answer in one sentence that planning is a mechanism for co-ordinating economic events in space and in time, and that by co-ordinating them in advance, *ex ante* instead of *ex post*, it has the possibility of eliminating alike the uncertainties and the fluctuations of economic activity which form an integral part of an individualist economy. In the latter such co-ordination as exists operates unconsciously (as it were) through the market and *via* price-movements ; in the former it operates by direct controls over production, consciously devised and implemented.

There are many who argue that the problems of peace-time are different from those of war, and that while planning may be suitable to the one it is not suitable to the other. But I do not believe that the essential problems are so different as economists have often made out. It has been said that in peace-time the ends are multiform, so that the problem of allocation of resources is altogether more complex. But are the basic problems of giving every man a job and securing to each family a sufficiency of the necessities of life—the problems of unemployment and of poverty—so essentially different in kind from the problems of war-time ? And if planning, and the subordination of particular interests to the general, are found necessary for the one, why not also for the other ? The system of priorities involved in securing a sufficiency of prime necessities to the mass of the population is not a very complicated one. Hitherto, indeed, the basic problem of peace-time economy has been to secure the utilisation of idle resources, whereas it is in war-time that full-capacity working imposes the stringent discipline of using scarce resources in an optimum way. The primary difference between the economic problems of war and of peace seems rather to be that between the pre-eminence of short-period and of long-period considerations ; and it is essentially the latter which raise issues of large-scale economic strategy, where the co-ordination of numerous interdependent factors and long-range vision are involved—questions affecting the relation of industry and science and technical innovation ; questions such as the location of industry, the relationship between industries and the introduction of new products and new methods. These are just the issues where the advantages of planning are paramount, and where what one may call the tactical questions of adaptation to a given market-situation, in the furtherance of which *laissez-faire* has been so often extolled, are of secondary importance. It seems fairly evident that if we are to avoid post-war economic dislocation and an economic slump of dimensions which may well put 1920 and 1929 in the shade, we shall need boldly conceived action by the State on an extensive scale. If this be the case, I suggest that we should do well to devote much more serious study than we have devoted in the past to the methods and the experience of that great country which by dint of economic planning has built so formidable a war machine, and which, in the words of *The Times*, ' has won ungrudging and imperishable recognition as the one military Power on the Continent capable of standing up for so long to the whole weight of the Nazi war machine ' (Sept. 6, 1941).

In the international sphere it seems utopian to expect in the post-war era a simple return to conditions of 19th-century free trade and free exchanges, as some people do. There are too many powerful interests entrenched behind the protecting walls that have been erected within the last two decades. Nor do I think that this is to be desired even if it were attainable. Freedom of international economic relationships is often inconsistent with the maintenance of full employment inside a country ; and it may perpetuate a situation where countries that happen to be rich in capital can permanently hold back the development of countries that are poorer in capital and are still industrially undeveloped. On the other hand, one would hardly need to say that the Hitlerian New Order offers us nothing but a picture of what to eschew, were it not that some writers have ventured to commend certain aspects of this New Order. The enlarged economic area which this claims to establish is one within which the metropolis fattens at the expense of satellite colonies, in which the terms of trade are deliberately turned in favour of the former and to the disadvantage of the latter, and industrial development at the periphery is held back, even reversed, to maintain a monopoly for the established industrial interests at the centre. It represents a system of scientifically calculated exploitation on an international scale, combining the worst features of modern imperialism and 17th-century mercantilism with a new serfdom in eastern Europe as its pedestal. The post-war world, it is true, will need larger economic

units and a greater measure of economic intercourse. But it will need this to be combined with the maintenance of full employment inside each national area, the ending of exploitation of weak nations by strong and an accelerated development of the more backward areas. This synthesis cannot, I believe, be achieved either by a return to the nostrums of traditional free trade or by means of Empire groupings, patterned consciously or unconsciously on Hitler's New Order. It demands an entirely new régime of international planning based on the democratic association of co-equal units. Such planning raises immense problems that cannot be summed up in an aphorism. It may well involve insuperable difficulties so long as the vested interests of monopolistic groups still reign within each national area. I can only add my conviction that a solution is to be sought less in terms of inventing new machinery to be erected on an existing base than in terms of change of system internal to each country : that a solution to these problems in the world arena will be very much nearer if successful planning of economic life within each national area has first of all been achieved.

In conclusion I would like to emphasise a *caveat* that I hope has been implicit in what I have already said. There are many things to which the name of planning is popularly given—too many for clarity of thought. It must not be supposed that all things to which the name is given are of equal value. In particular, I think that a sharp distinction needs to be drawn between what most of us really intend when we use the term and the sort of sectional planning of restriction of which we have seen so much in recent years : planning, sometimes honoured with the title of ' self-government by industries,' which so commonly means in practice planning for monopoly by sectional interests, the chief concern of which is to maintain the value of existing assets and to keep high-cost methods in use. This sort of planning has been aptly described as ' making one blade of grass grow where two grew before.' To be worthy of the name, planning must be governed by the general interest, not the sectional ; it must be armed with the powers necessary to subordinate private interest to social interest and to make the common good paramount over individual profit. About the institutional foundations and the political and social prerequisites of a planning such as this, it is not my place here to speak. I would repeat only that there is one revolution of attitude and of principle, that I believe is even more vital to such social planning in post-war reconstruction than it is to efficient war production to-day : namely, the ascendancy of the claims of those who work over the claims of property, instead of the converse which has been the traditional basis of economic and social life hitherto. This I believe has to be brought down from the plane of rhetoric and made the keystone of our actual building, not only because human life and livelihood have a meaning in social accounting which property-values have not, but because it is the working producer—the man at the bench, in the office or in the laboratory—who is the active element in economic life, whose initiative successful planning will need to evoke and to harness, whereas in modern economic life the interest of the property-owner is increasingly passive, *rentier* and absentee. Here, in achieving a new union between science and labour in social planning, I would respectfully suggest that the scientist, as much as, in some ways more than, the economist, has a very high responsibility.

Mr. O. Arup

THE development of modern science and technique enables us to construct buildings which are satisfactory in every respect : warm, soundproof, well ventilated, with all the amenities and labour-saving devices which one could wish for. Modern buildings as actually constructed, however, are not nearly as wonderful. They are often badly planned, badly ventilated, badly heated, etc. In other words, only limited use is made of all the existing technical knowledge. One reason for this is simply that this technical information is not available to the designer of the building. This may be because he has not got the knowledge he ought to have, but even if he were a very able architect with the best possible technical education, he could not hope to be familiar with the complete range of modern technical possibilities. He is, therefore, unable by himself to arrive at the right solution, and is a prey to the various commercial interests advocating their own particular products.

The problem is the same here as in other spheres of human activity—a wealth of new knowledge, new materials, new processes has so widened the field of possibilities, that it cannot be adequately surveyed by a single mind. Corresponding to this increase of means there are increased or entirely new requirements to be satisfied. Our needs increase with the means. Standards are raised, new services introduced.

This produces the specialist or expert, and the usual problem arises how to create the organisation, the ' composite mind ' so to speak, which can achieve a well-balanced synthesis from the wealth of available detail. This is, I suppose, one of the central problems of our time. How then can we overcome this difficulty ?

Apart from the obvious way of improving the technical education of the architect, which, however desirable, would I am afraid not carry us very far in this connection, there are two main remedies.

(1) One is to have the planning carried out by a team of experts whose combined knowledge covers a substantial part of the relevant technical information.

(2) Another is to have all the technical information which may have a bearing on the problem checked up, classified, standardised and made easily available.

Both these methods are being employed, but not sufficiently.

The architect does, of course, invoke the assistance of various specialists, but mostly at too late a stage to affect the main conception.

Take for instance the case of the structural engineer, his work has a fundamental bearing on the planning, and architectural harmony can only be achieved if architect and engineer collaborate intimately right from the start. At the moment, there is however no recognised

machinery for such collaboration. The appointment of an architect does not as a rule carry with it the appointment of a consulting engineer. The architect must therefore either :

(1) confine himself to employing a more or less established structural system of which he has sufficient knowledge himself ; or

(2) he must entice a consulting engineer to collaborate with him ' on spec ' ; or

(3) he must seek advice from a firm of structural engineers and contractors who will offer this advice possibly from purely altruistic motives, but possibly also in order to improve their chance of obtaining the contract by putting the architect under some sort of obligation to them.

This sort of semi-collaboration does not produce the best results. Similar remarks apply to the collaboration with other specialists.

One remedy, as mentioned, which is already being applied in some cases, especially in the U.S.A., is the formation of larger planning units consisting of firms or companies who have on their staff experts on the various aspects of the work to be planned. The organisation may be on more or less democratic lines, but the importance lies in the fact that the various experts are in constant close co-operation and learn to understand each other's points of view, so that each can see his work as part of a whole plan, and make the adjustments required for smooth dovetailing. The value of such close co-operation can be seen in every sphere of planning.

Of special importance is the close connection between design and execution. A thorough knowledge of building costs and building processes is essential to the designers, and this knowledge is best obtained if he, or his team, directly control building operations on the site, thus taking over the function here carried out by the general contractor.

Such larger planning groups are also in a better position to cope with the modern trend towards pre-fabrication in building. Pre-fabrication obviously means studying factory production, and calls for team work. In fact the spread of pre-fabrication will in itself tend to eliminate the private architect. His place will be in the factory, or inside the public or private planning group.

The trend towards the formation of larger planning groups on a commercial basis which is already apparent has, however, serious drawbacks. One of the major purposes of each group is to be successful, to make profit. This may fit in with the interests of society as a whole, but often it does not. The group will try to keep its experiences secret, it may be financially interested in certain materials or certain processes, and may want to push them even if this does not make for the best possible scheme. It may even buy up and suppress new inventions, and will tend to turn any gain of efficiency into increased profit rather than benefit to the consumer.

Then again, no group covers a wide enough field. The client therefore still needs expert advice to enable him to choose between the bewildering variety of possibilities, and when large-scale planning is undertaken, the work of the various groups should again be co-ordinated, for which there exists no machinery.

Team planning of this kind does not solve the difficulty of discriminating between many new materials and patent processes, information about which is only available in the form of biased trade publications.

We therefore turn to the other remedy—the creation of a fund of unbiased information available to all. This would mean the setting up of institutions working for the benefit of society as a whole, which would therefore probably have to be financed by the State. I enumerate at random some of the services which should be rendered. One would be the proper scientific testing of all new, and for that matter old, building materials. No new materials should be generally released without having passed such tests, and the results should be available to the general public. This sounds reasonable and innocent enough, but it would have far-reaching consequences. The authorised testing institutions would require permanently, powers that are contrary to the interests of some commercial firms, which are therefore rarely given, and then only for a limited purpose and period, namely, those of a governmental commission of inquiry. To publish unbiased information, however, should logically be followed by a restriction of production to useful products, and would therefore interfere considerably with the present organisation of industry. To have this unbiased testing extended to building processes, tools and plant, would obviously also be very useful and result in enormous savings, but it would call for large research stations with ample staff and resources.

Another would be to eliminate some of the unnecessary repetition of detail planning which goes on in thousands of offices. Everywhere the same or almost the same problems crop up, and are painfully solved over and over again, sometimes reasonably well, often not so well. If the best possible solutions were found to these problems and embodied in a series of standards, the task of the designer dealing with a particular job, and also production generally, would be simplified immensely. Standardisation has, of course, been carried out to a great extent already, but the process could be extended much further, provided there was a reasonable choice of alternatives, and the possibility of revision was safeguarded.

Such a systematic standardisation of the elements of industrial planning should logically embrace international agreements on the fundamental standards, such as measurements. To be forced to translate Kg. per sq. cm. into lbs. per sq. inch, etc., is wasteful, and hinders international exchange of ideas.

Hand in hand with the standardisation of these units from which planning proceeds, should go the standardisation of human needs. Minimum housing standards, workshop standards, etc., should be laid down and applied universally, and from these should spring building regulations, etc., which should safeguard the interest of society as a whole, but should not be drafted so rigidly as to be a drag on progress. The service must be run on democratic lines to allow revisions and additions to penetrate from below, from local to central bodies, to avoid over-centralisation, and bureaucracy, and allow for regional differences. But there must somehow be power to direct or

influence production. The centre of gravity must be shifted from private enterprise to public service. The best brains should be attracted to this service, and it would be reasonable and profitable to combine these planning and research centres with the technical education of students.

Once the principle is accepted, that the public has a right to expect the elimination of the obstacles which prevent the application of scientific and technical progress, it is not easy to stop half-way. Organisation of industry and communications, the planning of towns and agriculture, the extension of social services are all problems which, as far as I can see, cannot possibly be left to private initiative, but which everybody now realises ought to be tackled in the interest of humanity.

To take an example, the proper heating of houses and workshops in the winter, and the supply of hot water on tap, could be made a public service by the introduction of district heating supplied from a number of central heat-electric stations which would combine the generation of electricity with the supply of heat in the form of superheated water. Such a system would considerably reduce the total coal consumption, and would at the same time supply an abundance of electric power which could be used for heating in outlying districts. It would also affect the design, and reduce the cost of new buildings, and would improve housing conditions where improvement is most sorely needed. Again, however, such schemes could only be tackled on a national scale.

It becomes more and more clear, therefore, the more one delves into the question how the benefits of modern technique can be made real, that this is not a technical problem at all. It is not even mainly a problem of organisation. The organisation could no doubt be worked out if everyone really wanted to benefit humanity. The difficulty is rather one of getting agreement as to what benefit to humanity means, and also of overcoming the fact that people are more concerned with benefiting themselves than humanity. It becomes therefore a moral or social or political problem. It should be obvious to scientists and technicians that the value of their work depends on the solution of this social problem, and they should therefore, as citizens with a social conscience, do everything in their power to contribute to its solution.

Dr. O. Ziegler
An International Transport System

THIS communication dealt with what a rationally extended international transport system could do to ease social tension. Transport has exhibited a really revolutionary development during the last hundred years ; for until the introduction of railways it remained in a lethargic condition for about two thousand years. Since 1835 the rapidity of travelling has risen from ten miles an hour to more than two hundred miles an hour. Thus the world has apparently shrunk to a twentieth of its size. We know from history that even in ancient times the agglomerations which became centres of culture and trade grew up on transport routes : at ports, and on rivers, roads and the routes of caravans. In recent times we know of the rapid growth of towns in America and the Soviet Union which grew up on important lines of communication. Great stretches of the earth's surface, however, are untouched by modern transport. Not only on the Asiatic and African continents, but even in Europe, there are such areas. They stretch from the east to nearly the middle of the continent.

The speaker was specially concerned with the south-eastern part of the Danube basin, which is not linked up with western Europe by an adequate transport system. Here 75 per cent. of the population live in a state of poverty, mainly on extensive agriculture. The areas under cultivation are much over-populated, and the birth rate is high (10·3 per 1,000 as against 3·2 per cent. in the United Kingdom). There is a danger of further splitting up of the minute farms (average size in Rumania, 6·4 acres). The absorption of the excess population into industry, which has expanded somewhat in recent years, is not sufficient as industry is hampered by the lack of transport and capital. The question of capital would be easier to solve if the transport problem were satisfactorily settled. Yugoslavia, for instance, is the richest land in raw materials in south-eastern and western Europe. But a glance at the map of Bosnia, the part of the country richest in ores, shows that there are neither railways nor roads enough leading to the mineral deposits. Rich forest land and metal-bearing districts in other parts of south-east Europe are also under-exploited or not exploited at all.

The standard of life in these parts of Europe, which is so important to the production of raw materials, is extremely low, about a quarter of the income in central and western European countries, or one-sixth of what is earned per head in Great Britain.

The speaker compared the road and rail development and the volume of foreign trade of the two western Danube States, Czechoslovakia and Austria, with those in the south-east (Hungary, Jugoslavia, Rumania and Bulgaria), and pointed out that the former, although possessing less than half the population, had, thanks to their better organised transport system, 2·48 per cent. of world trade in 1936 as against the latter's 1·78 per cent.

Reference was also made to the social criterion of motor ownership in proportion to the total population. The Czechoslovak Republic had one car per 119, Austria 1 per 147, Hungary 1 per 504, Rumania 1 per 797, Jugoslavia 1 per 1,172, and Bulgaria 1 per 1,344 inhabitants, as against 1 per 21 inhabitants in the United Kingdom.

In conclusion, the importance of the development of transport in providing labour and in the acceleration of numerous subsidiary industries, trades and crafts, was pointed out. The building of motor roads will facilitate the absorption in peace-time production of the motor industry which has been greatly expanded during the war. If transport can contribute to raising the standard of life in south-eastern Europe to one-third or to half of that of western Europe or the United States, it will furnish employment, through the expected increase in exports, to tens of thousands of workmen in western Europe, and keep numerous industries employed.

Prof. E. J. Bigwood

EVERY great scientific discovery has left its mark on the social structure. If any new movement needs to be started, it is the attempt to co-ordinate such influences more and more on an internationally planned scale. In that, however, we cannot claim to be pioneers. It would be unfair not to refer to the very useful work undertaken in recent years, with that particular object, by the international committees of the Health Section and other technical sections of the League of Nations, by the International Labour Office and the International Office of Hygiene, and also by the international meetings periodically held by various scientific organisations.

Our object must be to continue these efforts, to develop them, and to improve on what has already been achieved. Moreover, they have been interrupted by the war, and it is our task to take them up again in the future. Even in purely scientific work it has been felt necessary to co-ordinate efforts on an international basis, for instance, in the direction of standardisation of terminology.

Now it is easy to see that a distinction must be drawn between the endeavour of scientists to co-ordinate their efforts in the direction of suggesting measures to improve welfare, well-being, public health, mutual understanding of their scientific activities, etc., and the means by which such co-ordination can be put into practice. Such efforts have often been wasted because of the lack of concentration on the means of putting into practice what has been agreed upon. If such a situation has arisen it is for several reasons, of which I might quote two as typical examples among others.

In some cases a scheme, although it seemed to be good, has not come into practice because of subjective considerations in connection with nationalistic one-sided standpoints or feelings of personal pride coming into play ; in other cases it was because the measure itself may not have been really advisable, but was nevertheless pushed through by active and convincing defenders, or its inadvisability was revealed only by subsequent experience. This leads us to consider that planning may have disadvantages as well as advantages, and it is good that we should keep this in mind when we are right in contemplating the prospect of planning. A few examples may help to make the point clear.

Planning for the international standardisation of certain principles for the assessment of the physiological activity of biological preparations, and of the choice of proper units for measuring and evaluating such activities in comparable conditions, is an example of only one of the achievements of the League's Health Section. It is one of the best examples of good and useful international planning. Let us now, in contrast, take an example of efforts which led to less happy results. Everybody will agree that some standardisation of scientific terminology is badly needed. Different words are used to refer to the same thing, or a single word often has various meanings. Attempts have been made in this direction by important scientific societies. New carefully thought out words have been proposed unanimously by international committees officially appointed for the purpose. These words have been only partially adopted in practice throughout the world. The result has been that instead of tending to diminish the number of words used to refer to the same thing it has in fact tended to increase them. The result has been to make the situation worse, not better. Notwithstanding the fact that some standardisation is badly needed in terminology, we have to bear in mind that the significance of many words is bound to evolve with the ideas they refer to, and move with knowledge. I always remember the answer of a prominent scientist to one of the members of a scientific meeting who was complaining that such and such a word had really no sense. The reply was that that did not matter as long as everybody knew that nobody knew what the true meaning of the word was.

Finally, I should like to insist on another example, one of which our meeting has spoken at length, because of the importance that it rightly attaches to it for future planning. I refer to nutritional standards. First of all I believe it is fair to say that the Health Section of the League of Nations was again the first to endeavour to establish such standards on an international basis. Indeed, I am in full agreement with Sir John Orr's point of view of the necessity of using standards to solve the problem of improving the nutrition of the masses, but I believe that we must bear in mind the exact meaning we give to the word 'standard.' From the social point of view, that which deals with problems of public hygiene, etc., nutritional standards refer to a justified concept. They are indications, elements of reference which serve as a general guide for characterising a state of affairs, and helping to improve that state in the light of most recent scientific knowledge, and we therefore need the help of the scientist in setting them up.

Do not let us imagine, however, that the social worker simply makes use of scientific standards of nutrition which are put at his disposal. This would give quite a wrong insight into scientific achievement. There are standards used by scientists as instruments for work. But as far as scientific thought or knowledge is concerned, continuous change is its most specific feature, and this is exactly the opposite of what the word suggests ; that is to say, something definitely fixed and invariable. Let us suppose that we had decided to set up our nutritional standards a week before Vitamin C was discovered. We would never have dreamed that oranges, lemons and certain raw vegetables must be included as essential factors in our standards when we worked them out in terms of foodstuffs.

Let us call for the help of the scientist in our social work. We shall never do it too often. But let us not, in return for such valuable assistance, fall into the error of dragging science into some sort of degraded form which may result from 'vulgarisation.' For practical purposes, the social worker has necessarily to simplify facts, hence to deform them somewhat. Let us remember that standards must take the form of a simple device, whereas individual requirements are complex, subject to infinite variation with circumstances and with individuals. Standards are rough but useful general indications to be followed for the sake of a general trend of improvement of multiple

complex abnormalities. They must necessarily be revised and adjusted as time passes, as conditions of living are improved and as knowledge grows. They are useful tools to be put in the hands of social workers when they are properly warned of their exact meaning, and when they are fully conscious of the fundamental fact that there is no such thing as a standard in the field of purely scientific thought.

Major Herbert Noyes
Post-War Land Settlement Abroad

In the post-war planning of Europe, so far as our own efforts are directed towards the establishment of an ideal New Order, when the war is ended, we must not lose sight of our own immediate problems. For those to whom an open-air life appeals—and there will be many—a partial solution of the unemployment problem which will assuredly face them might be found in advance by formulating a tentative plan of assisted migration in readiness for the day when it will be needed, with the co-operation of the Dominions concerned. The success of such a project should not be endangered by dwelling upon past failures in the field of Empire settlement. The majority of these are explicable to persons with practical experience of colonial life and conditions, the trouble being that such qualified persons are rarely consulted. I have in mind land settlement schemes in South Africa at the end of the Boer War and in 1919 when openings for officers and men were many and various. Some were put forward in a spirit of pure altruism, others were swindles. No single group settlement scheme has succeeded in South Africa, unless we except the original 1820 settlers as a modified success, although an attempt to resuscitate its activities of late years did not meet with the success it deserved. Government land for group-settlement in Africa is available to-day, but unless the participants can afford to employ native labour its future holds little promise.

There are opportunities for mass migration both in Angola and Northern Rhodesia, and many difficulties in the way of founding a home in either. But they are purely economic and therefore not insuperable. For those who have lived and worked under the equator know that the dictum that tropical countries are not suited for settlement by whites is a fallacy. At Lubango in Angola whites have been doing tilling, sowing and harvesting since 1885 and form a flourishing community; in Queensland the sugar industry is carried on solely by white labour; in Kenya I have seen the settler working as hard as the native; in the West Indian island of Saba a white community has been settled since 1644; at Ste. Katarina and Espirito Santo in Brazil many thousands of Germans are doing their own field work. In the tropics, I have found that disease, not the sun, is the enemy of man.

Australia provides more scope for an energetic land-settlement policy than any other country I know. Failures in the past—and they have been grave—are to the expert not difficult to explain. Many of them were due to the lack of careful selection of the type of man sent out. It is not suggested that the authorities were entirely blameless in their choice of land or that drought was wholly accountable for the last débâcle. But there should be no repetition of similar blunders and those who are apt to stress them should remember the outstanding successes of many settlers in Australia in the business of stock, grain, fruit and wine.

There is room for some six million settlers in Australia, but I doubt if there is sufficient State land available for that number. But in one sparsely-settled corner there is still space for, say, three million families and land to be bought from ten shillings to thirty shillings an acre, freehold. I know it well. It has an ideal climate, a constant rainfall of 45–50 inches, good soil and markets near at hand; timber is plentiful in the neighbourhood, and transport is easy. Settlers already established there are concentrating on dairying and fruit-growing and, working on a co-operating system, are flourishing exceedingly.

Canada is beyond the scope of this paper, but facilities for acquiring exact knowledge of that vast and wonderful country are within the reach of all.

Mr. A. E. Margolis
Improvement of Climatic and Living Conditions by Public Heat Supply

In large towns human activity creates climatic conditions worse than those of the open country. We may therefore differentiate between the climate of urban and rural areas, just as we do between continental and maritime climates. The deterioration of the urban climate is principally due to industrial development with an ever-increasing demand for heat, for heating, process work, light and power, generated mainly by burning of bituminous coal. Air pollution caused by the smoke of industrial furnaces and domestic fires is so intense that pollution from other sources, such as traffic and process work, is almost negligible. Most of the smoke is due to domestic fires—for London it has been estimated to be about 2½ times as great as that from industrial furnaces. Owing to the mild climate a vast majority of buildings in this country are still primitively heated by open coal fires with a poor efficiency in heat utilisation but with a high efficiency in air pollution. Owing to the poor thermal efficiency of coal-fires and to the high retail coal prices, heating in this country is expensive, and it is quite usual for many rooms, even bedrooms, to be only occasionally heated or not heated at all. In consequence, dampness cannot be avoided, and this is probably the main reason why so many people in this country suffer from rheumatic diseases.

The material loss and damage due to smoke has been estimated to amount to between ten and twenty shillings per head of the urban population. But much worse are the evil effects of smoke and fog upon public health both bodily and mentally. It should be noted that an adult person consumes about 30 lbs. of air per day, which is ten times as much as the consumption of solid food and about seven times as much as the consumption of water. The provision of pure healthy air is therefore nowadays hygienically as important as the supply of potable water. Of equal importance is the provision of ample and cheap heat for domestic hot water supply

and space heating. The social problem of rehousing great masses of the population in healthier and more spacious dwellings cannot be solved without adequate heating. Even modern dwellings do not fulfil their purpose if the rooms are not properly warmed, and in consequence, the living space of the family in the winter is confined to one room or even to a small part of a room around the fire.

This problem can nowadays be solved by general introduction of district heating. The total amount of heat required for space heating, hot water supply and process work can be generated in big stations located outside the town. The transmission of heat has already been carried out to a distance of six miles, and there are no special technical difficulties in transmitting heat an even greater distance, and in providing large cities with complete heat distribution systems, in the same way as for water, gas or electricity supply.

The burning of coal is a complicated physical and chemical process, and the highest efficiency in heat utilisation and also in smoke prevention can be obtained only in big plants with up-to-date equipment and with a specialised staff. An average efficiency of 85 per cent. can nowadays be easily obtained, compared with only 20–25 per cent. with coal-fires. Simultaneously, by introduction of district heating the thermal efficiency of electric power stations will be increased from 25 per cent. nowadays up to 80 per cent., because the waste of heat with the cooling water will be completely eliminated. In Soviet Russia district heating is a part of the electrification programme and according to the current five years' planning, 1938–1942, the capacity of all thermal power stations is to be increased by 7 million kw., out of which 5 million kw. are to be installed with back-pressure and extraction turbines for heat supply.

From the standpoint of our problem, it is most important that the flue gases of big stations can be cleaned by electrostatic precipitation or other methods. Equally the dust, fumes and vapour of all kinds of factories can nowadays be effectively eliminated.

By confining the burning of fuel to a few generating stations located outside a town, all smoke and all nuisance created by it would be eliminated from the town itself, and the air, at least in the districts without heavy traffic, would be as clean as in the country.

With regard to the fog nuisance, conditions in the town would be better than in rural districts. At present fog which is carried by the wind from the country into the town is intensified by mixing with the smoke-laden air, and can hang over the town for hours or even days when the air is still. In the future, when district heating is generally adopted, the country fog carried into the town would be dissipated by mixing with the clean and warmer air of the town.

It must be further considered that the smoke-polluted air of the big centres of the population is dispersed over wide areas of the country and results in an enormous increase in the number of nuclei for formation of fog. It can therefore be assumed that, with the general adoption of district heating, the frequency and intensity of fogs will be diminished also in rural districts. In consequence the amount of sunshine will be increased not only in towns but to a certain extent even in the country.

The provision of healthy air and more sunshine will also have an effect upon the distribution of the population and upon future town planning. It will modify the movement from towns to places outside, dormitory towns. This movement has extended the main source of air pollution ; but the centralised supply of heat would create a new economic basis for town planning, with shorter distances between places of business and residence and with a simplified traffic system, and consequently with less strain, less waste of time and reduced travelling expenses for the population. Furthermore, first costs and running expenses for new railways, roads and streets and for all supply services as well would be considerably reduced.

This method of improving climatic and living conditions in towns appears grandiose ; nevertheless it can be realised on an economic basis, and there is hardly any problem of such vital and hygienic importance as the provision for the urban population of ample heating, healthy air, and more sunshine.

Rt. Hon. the Earl of Onslow, P.C., G.B.E.
Science and the Conservation of the Wild Life of the World

If science is to advise on world planning, it cannot afford to overlook the relation of man to the wild life of the world. This wild life—fauna and flora—is an international heritage which is in danger. Since the evolution of man has taken place, not only alongside of, but as part of the evolution of the fauna of to-day, scientific consideration of man's needs must take account of his part in and dependence on the world ecology, varying geographically through differences of physical conditions, but governed everywhere by the same fundamental principle of interdependence.

With the aid of science, man has achieved an appreciable measure of control over his environmental ecology ; and, according as that control is exercised wisely or unwisely, with forethought and moderation, or greedily without regard to consequences, man stands, in the long run, to gain or lose by it. If, in the exercise of that control, always limited by the fundamental forces of nature, he utterly destroys some part of the ecology which is so important a part of his environment, some species or group of animals or trees for instance, to that extent he disturbs the balance of nature and may sow the seeds of unforeseen mischief. And that mischief may be irremediable ; for, certainly, what has been thus destroyed cannot be recreated. Moreover, even if no substantial damage to man's material interests results, something of intellectual and æsthetic interest has been lost for ever. Man in the present has failed in his duty as trustee for man in the future.

Too many species of animals have already been exterminated through the agency of man, some of them within living memory, and others are in danger of extermination. Among the former are the quagga and the blaaubok of South Africa, the

Antarctic wolf of the Falkland Islands, and among birds, the great auk and the passenger pigeon of America, the latter within comparatively recent times uncountable in its millions, and now extinct. Among those in danger of extermination are such as the wild horse, the South African blesbok, the white-tailed gnu, the Javan rhinoceros, the Australian koala and the Tasmanian thylacine, to cite only a few.

These may have been the victims of direct attack by man ; but great damage may be done on a more comprehensive scale through operations undertaken to develop a region for occupation and exploitation by men which gravely interfere with the natural ecology, and deprive the fauna which forms a part of it of a habitat which gives it the conditions essential to life. The commonest of these harmful operations are deafforestation on such a scale as to interfere with the rainfall, and ill-considered schemes of land drainage. Both of them are liable, as experience in the American and African continents proves, to bring about soil erosion, to the prejudice, not only of wild life, but also of human economy. Soil erosion may also result from overgrazing, which, in turn, is the outcome of overcrowding of grazing animals within a restricted area, in consequence, it may be, of the destruction of their natural enemies, the great carnivores, or of their expulsion from a great part of their natural grazing area. It will thus be seen that the ultimate fates of fauna and flora are inextricably interwoven and that the problem of the conservation of wild life is one of an intricate ecology demanding scientific study and the application of regulations based upon scientifically sound conclusions.

The Society for the Preservation of the Fauna of the Empire believes that the case for which it stands is scientifically sound as regards its broad principles and merits the warm support of a scientific congress devoted to the planning of a programme of both economic and cultural reconstruction after the war. That wild life conservation has an economic value has already been indicated ; but it may be worth while to cite briefly some of the more obvious cases where the economic necessity for conservation has engaged the attention of science. The excessive exploitation of the life of the sea—in particular, fishes and cetacea—has been the subject of intensive study through the agency of such organisations as the International Council for the Exploration of the Sea and the Discovery Committee respectively. In both these cases the rapid development of increasingly powerful and efficient means of capture, coupled with unrestricted international competition, was found to have brought about a situation in which resources formerly believed to be inexhaustible were, in fact, being exhausted. It is doubtful whether, even in the case of the whales, complete extermination of further species was threatened. What was threatened, and, to a point, had already come about, was the failure of the economic productivity of these resources. The sequence of effect on cause might, in these cases, with a little reflection, have been foreseen ; but, in both, the study of the condition of the stocks and the suggestion of remedial measures demanded broad investigation of the whole ecology of the habitat of the animals in question. As a result of these studies conventions or agreements have been brought into force, which, though they do not go to the whole length advocated on scientific grounds, are, so far as they go, based on scientific data and conclusions.

A less foreseeable case of the need, for the preservation of human interests, of fauna conservation is that of the increase of bubonic plague in South Africa, which appeared to be traceable to the uncontrolled destruction of the smaller carnivores and the snakes, leading to a notable increase of the population of rodents, including those that were carriers of the plague.

A case directly comparable with those of the whales and the fishes arises in parts of Africa, where the meat of game is an essential part of the diet of the native population and it is therefore essential to conserve the supply, and, especially, by regulation of hunting and poaching, to protect the natives against the results of their own reckless exploitation of their natural resources.

Apart from the economic aspect of the conservation of wild life there is another not less important. It is the business of science not only to minister to the material needs and comforts of mankind, but to have regard, also, to man's intellectual and spiritual development. The study of his biological environment should be regarded as an essential part of man's training for life, and appreciation of the beauties of nature —not merely individual beauties of form and colour, but also the rhythm of nature's finely balanced ecology—as an invaluable influence in his intellectual and spiritual development and outlook.

It is out of regard for all the foregoing considerations that the Society for the Preservation of the Fauna of the Empire, since its foundation in 1903, has urged the cause of fauna preservation especially in Great Britain and the colonial empire, and, more generally, as active propagandists, in the Dominions and throughout the world. As a result, in the main, of the activities of this society an international conference was held in London from which resulted the London Convention relative to the Preservation of Fauna and Flora in their Natural State (Africa) signed, in 1933, by the representatives of the Union of South Africa, Belgium, Great Britain and Northern Ireland, Egypt, Spain, France, Italy, Portugal and the Anglo-Egyptian Sudan, and subsequently ratified by the Governments of Great Britain, Belgium, Egypt, Anglo-Egyptian Sudan and South Africa.

A conference of wider scope was to have met in London in 1939. At this conference it was hoped both to improve upon the African Convention and to extend its provisions to embrace Australasia and Oceania. Owing to the outbreak of war this conference had to be postponed, but it is the hope of the Society that it may take place after the war, and that, eventually, the principles of the African Convention will be applied all over the world by means of one convention employing methods as nearly uniform as geographical variations permit. The recent signature by the United States and the majority of the South American republics of a convention, following the general lines of the African Convention, applicable

to their respective territories, encourages them in this hope.

The principle underlying the African Convention is that, while development of the resources of each country for human benefit must be the first consideration, the preservation of indigenous fauna and flora is so important on economic, intellectual and æsthetic grounds, that it must be regarded as an essential part of any rational scheme of development. In particular, the convention provides for the creation of national parks, of which the outstanding examples in Africa are the Kruger National Park in South Africa and the Parc National Albert in the Belgian Congo territory. Both cover very large areas, that of the Kruger National Park being approximately commensurate with the principality of Wales. Both are dedicated to nature in the sense that the natural fauna and flora are to be left undisturbed for ever except in so far as the development of roads, rest huts, etc., within the park for the convenience of visitors desiring to study, especially, the fauna and flora may require. The Society attaches most importance to national parks because they are, according to the strict interpretation of the African Convention, inalienably dedicated to nature, and at the same time offer facilities for instruction and recreation to all comers. It has been learned recently, with great satisfaction, that a national park has been established in the Serengeti district of Tanganyika Territory, the first of its kind in a British African colony. The convention demands the establishment of similar parks wherever possible.

Other methods of conservation encouraged by the Society and provided for in the convention are the establishment of strict nature reserves, which are absolute sanctuaries not open to the public, and game reserves, in which controlled shooting is permitted under licence, and the general regulation of shooting, the prohibition of certain methods of hunting and the absolute protection of rare or threatened species.

National parks, nature reserves and game reserves, while they provide sanctuary, entire or partial, for wild life, also form reservoirs the overflow from which helps to keep up the supply of meat for the native population. The various regulations serve the same end by preventing destructively reckless exploitation. All methods are designed to serve the fundamental purpose of preventing the extermination of any species. The national parks and other reserves, by keeping intact vast tracts of forest land, tend to conserve humidity and induce rainfall, and thus play a part in the prevention of soil erosion.

Both on economic and material and on intellectual and scientific grounds there is, then, good reason why science should give its aid in the effective conservation of wild life. And the case is one for world-wide planning. For the whole of mankind, irrespective of race and geography, has from the cultural point of view an interest in this great ecological heritage, and no nation has the right to destroy or permit the destruction of that which, though it may lie within the boundaries of its territory, belongs, nevertheless, to every nation and individual.

SCIENCE AND TECHNOLOGICAL ADVANCE

SATURDAY, SEPTEMBER 27 : AFTERNOON SESSION

CHAIRMAN : H.E. THE CZECHOSLOVAK PRESIDENT, DR. E. BENES

The Chairman

I CONSIDERED it as a very great honour both to myself and to my country when I was asked to preside over this meeting of the Conference, in which so many distinguished and free scientists from so many countries are taking part. During the last twenty years my country was one of the most progressive and developed democratic states in continental Europe and science and technology played a decisive part in its progress and prosperity.

My great predecessor in the office of the President of the Republic, President Masaryk, was a philosopher and scientist. In our political practice we both always tried to combine, in the life of the state and nation, politics with science, freedom with scientific criticism, tolerance ahd objectivity with democratic sincerity and firmness.

Hitler did not like to have such a dangerous state in his immediate neighbourhood, and Nazi violence decided to subjugate this island of democracy and freedom. The whole national Czech culture was destroyed. We had three great highly developed, modern universities ; we had ten other high educational institutes on the level of the university, several technological high schools, high agricultural, industrial, commercial and mining schools, medical faculties and other high schools and institutions ; we had hundreds and hundreds of middle schools of all kinds—all these were closed and confiscated, plundered and destroyed. We always proudly emphasised that we are the nation of John Comenius, the famous international educationist, who was the father of the modern European schools and modern school-education, and who, being in exile during the Thirty Years' War because of his fight for the freedom of religion and free thought in the period of the great religious wars on the European Continent, was invited to England just three hundred years ago by the British Parliament, came to this

country, and tried to win acceptance over here for his ideas regarding education, science, and social philosophy. In the arms of our Republic there is the watchword 'Truth prevails'—this means that science, objectivity, tolerance and justice prevail.

And the country which was governed in this free, scientific and tolerant spirit is now in the hands of Nazism. You will certainly understand what this means. And it is for this reason that I am so glad to have this opportunity to be amongst you to-day and to declare with emphasis that the whole Czechoslovak nation is with you also in the hope and conviction that they will be free again very soon, and that the principles of free government, of free science and human dignity will again become the basis of the whole national Czechoslovak life, as soon as the victory of the free European man has been achieved.

I have been asked to preside over this meeting. The reason lies perhaps in the fact that in my position at or near the head of affairs of a state I gained as close an acquaintance as anyone with the impact of technology upon the problems of modern social—and even individual—life. And in my previous capacity of Professor of Sociology also I was impelled to develop certain views and judgments regarding the rôle of technology in the life of modern society; and you will perhaps allow me to say a few words on this subject.

Philosophers of technology and sociologists usually emphasise, and rightly, how profoundly the growth of modern inventions has affected the spiritual and material conditions and development of general civilisation. And you know that there have been many controversies regarding the significance of this far-reaching fact. Some of these philosophers have developed a rather exaggerated philosophy of history, according to which the development of human civilisation in general is actually identical with the development of technology. In this direction lies the way to historical materialism. It is, of course, an incontrovertible fact that every invention is a new factor in the development of human civilisation. Having a direct influence on the forms of human labour, a technological advance directly and indirectly influences also all forms of social, political and moral development and the organisation of society in general.

The invention of the steam-engine, later supplemented by the electro-motor, caused a vast economic and social revolution in the 19th century and created what we call to-day industrial civilisation, the chief features of which are mass production by machines in factories, the formation of great urban agglomerations, an intensification of production and consumption, and the development of transport resulting in increased speed, volume and efficiency.

In politics the rise of industrial civilisation coincides with the downfall of feudalism, the coming into power of a new prosperous bourgeois class, and the establishment of a liberal and constitutional régime of government, which followed from the French, English and American Revolution at the end of the 18th and the beginning of the 19th century. From the sixties up to the end of the 19th century the modern bourgeoisie were the backbone of modern society, the symbol of the existing social order. The mass movement of the working class, which for the first time appeared clearly as a 'fourth estate' in the revolution in 1848, was its necessary corollary: the factory and its social and moral order, as well as the urban concentration of labouring masses, made this natural and necessary.

In the 20th century the steam-engine has been supplemented by the electro-motor, the steam turbine and the internal combustion engine, and these have meant a new epoch in the development of transport, the age of the automobile and airplane. Together with the telegraph and telephone, which had already become an essential part of modern life, they have achieved a new world wonder: distance has been practically abolished, space has been diminished, the transport of people and their communication over great distances has been perfected to such a degree that the world has become a unit to an extent hitherto unknown and unexpected. To-day you cross the Atlantic Ocean in a British or American bomber in seven hours.

It is an undeniable fact that this state of affairs has brought about a higher standard of life; that in many respects it has made the life of the broad masses of the people more agreeable and that it has raised its material and cultural level considerably. Intensified production has astonishingly enriched modern humanity. It has extended consumption, refined and raised the standard of life, broadened the material and cultural interests of modern people. Modern science and technology became a real basis of prosperity, happiness and unprecedented abundance for modern man.

On the other hand, there are, as you here in the country of Ruskin very well know, strong and rather pessimistic opponents of modern machine-civilisation, and especially of the consequences of modern technology. They emphasise the desolation and ugliness of modern towns and factories; the enslavement of man, who has almost been deprived of his soul in serving and following his

machines ; the devastation of nature ; the difficulties of the new social life ; the creation of the modern neurotic man with his restless mechanical and mechanised life. Technology, they say, by telephone, telegraph, railroad, radio and aviation, has drawn together the nations and states, has made the world smaller and made it interdependent to an extent hitherto unknown.

At the same time—and it is the most dangerous side of the consequences of modern technology—it has become to an incredible degree the instrument of nationalist and expansionist aims and of the possessive instincts of the so-called dynamic nations and states, the instrument of merciless industrial capitalist exploiters, and of ruthless political usurpers. Yes, it does raise the general cultural and spiritual level of the masses ; but at the same time, modern physics, chemistry and biology help to create gigantic armament industries, make possible the manufacture of bombs, poison-gas, tanks and bombing aeroplanes. Yes, chemistry and biology do assist in the improvement of the hygienic conditions of human life ; but certain states surpass each other in preparations for chemical and bacteriological warfare, without apparently realising what depths of moral insanity have been reached in consequence of the eventual misuse of the present enormous development of technology.

I am not, of course, among those who hold this pessimistic view. Technology helps to determine the development of human civilisation, and has helped to create new periods in human history and new social régimes. It is true, on the other hand, that while almost every great technical invention has brought with it many benefits to the nations, it has been used very often in such a way that it resulted in new troubles, evils, tragedies and catastrophes.

The present totalitarian dictatorship, after having suppressed the free science and the spirit of scientific criticism, misused every kind of modern free research, science and technology for the most disastrous and criminal undertakings. You have to-day nations which have been forced into a mechanised slavery, into a mechanised economic life, into a mechanised military and police machine. Some of you know, perhaps, the famous play *R.U.R.*, written by our well-known author Karel Čapek, in which he created the word and concept of the modern Robot. With the help of modern technology the modern dictators have tried to make their nations into military robots, and to use them for their criminal enterprises.

I think it has become obvious to all of us that the problem thus created is not one of the necessity of mechanical progress and of its justification. Every new invention of technology may bring unlimited social, economic and moral advantages, but it equally well can be misused for evil purposes, politically, socially, economically and morally.

Everything depends on by whom and how it is used. And this is not a problem of technology but a problem of human morals and enlightened human politics. The question is how to place the great inventions of modern technology into the hands of good, decent people in a decent and well-guided social and state organisation.

My conclusion is : this Conference of scientists is the manifestation of the urgent and categorical needs of the free world, to liberate subjugated science, to use science and technology in the post-war world for the work of real social reconstruction. But it is also a manifestation of our definite and firm will not to permit in the future the misuse of great inventions and all kinds of technological progress for criminal and destructive purposes, as is being done to-day on such a gigantic scale on the other side of the front. All that is happening to-day in Germany is nothing else than the greatest, the most distasteful dishonouring of the human spirit and of this high and noble activity of the human mind, which science has always represented.

Let us say quite openly that for the scientists the present war is a war not only for the liberty of the human spirit and human dignity but also for the definite victory of the free peoples, who will not permit again the misuse of the great achievements of science and modern technology for the barbarian killing and mass slaughter of peace-loving nations, for the wild destruction of the fine achievements of modern civilisation, and for the inhuman, brutal, and mechanised enslavement of whole nations by a band of men who believe that they represent a *Herrenvolk*.

Dr. C. H. Desch, F.R.S.

The Conservation of Natural Resources

THE natural resources of the world fall into two main groups. The one, represented by the products of agriculture and forestry, may be renewed, either annually or at longer intervals, by cultivation, and may be consumed as income, whilst the other, including mineral wealth, must be regarded as capital, and once consumed is not renewed. Soils should perhaps form a third category, for whilst they may be maintained in fertility for thousands of years, as in China, they

are only too easily ruined by careless or greedy exploitation, leading to exhaustion and erosion, or by mining operations, which may cause subsidence as in parts of England, or burial under debris through hydraulic mining as in California. This paper is mainly concerned with the conservation of those mineral resources on which modern industrial civilisation increasingly depends.

Mineral deposits have too often been regarded as inexhaustible, and it is only lately that the possibility of exhaustion in a measurable time has attracted attention. As industrialisation becomes more intense in Western societies and continually extends to regions which were purely agricultural, the rate of consumption of mineral capital is accelerated to an extent which is not always appreciated. Sir Thomas Holland has shown that in the first 25 years of the present century the quantity of minerals extracted from the earth was greater than that raised in the whole previous history of the world, or say 6,000 years since copper was first mined. A report to a committee of the League of Nations in 1937 by Prof. Högbom gave diagrams which showed that over a period of about 60 years the annual production of coal doubled itself in a little less than 17 years, of pig iron at about the same rate, of oil in 8½ years, of copper in 12½ years, and of tin in 18 years, the general trend remaining remarkably constant in spite of temporary fluctuations. Coal, for reasons mentioned yesterday by Sir Harold Hartley, ceased to increase after 1913, but in most instances, after an initial rate of growth which may be irregular, as for aluminium to-day, a stable rate is reached which gives a straight line when plotted logarithmically.

This does not mean that the production in any one country follows this law. The older producing regions may show a slower rate of increase, but this is compensated for by the opening up of new sources as the demand grows. It may seem impossible that such a fantastic rate of growth could long be maintained, but the standard of living which calls for such a consumption of metals and power as yet applies only to the Western nations. China consumes little metal, its enormous population depending on the use of renewable natural wealth rather than on mineral capital, but it represents a vast potential consumption, and the same may be said of India and, perhaps in a more distant future, of Africa.

It is extremely difficult to form an estimate of the existing mineral reserves. The total quantity of each element in the earth's crust, down to a certain fixed depth, has been estimated with some accuracy, and the figures are surprising. Nickel proves to be 10 times more abundant than lead and 50 to 100 times more than tin. Vanadium is more abundant than copper. But it by no means follows that they can be recovered in those proportions. For the most part metals are very finely disseminated in the rocks, and extraction is only possible where local concentration has occurred through geological causes. Nearly 90 per cent. of the world's nickel comes at present from a single great deposit in Ontario, and there are few other important sources. The deposits of tin are also highly local. The concentration which is necessary for profitable working varies very widely; thus the ore of the Rand may be worked when it contains one part of gold in 150,000, whilst hydraulic mining has been used on deposits containing only one part of gold in 3 millions. On the other hand, an ore containing 20 per cent. of iron is of low grade.

The estimates of world mineral reserves given by standard authorities fluctuate from year to year, but there is a certain complacency in the statement regarding some important minerals that the reserves will last for several decades. Where essential capital, which there is no possibility of replacing, is concerned we have to consider a more distant future. It appears that coal and iron may last for several thousand years, but the known reserves of oil, gold, tin, and perhaps copper, suggest a life of less than a century. That life may be extended in two ways: by the discovery of new deposits, or by improvements in methods of mining and extraction. The first is always possible, and there are regions such as the mass of ancient rocks in Canada still covered by forest which may prove to be valuable, but the areas unsurveyed are constantly dwindling, and there are vast regions which are mineralogically barren. By far the greater part of the mineral production of the world comes from countries bordering the North Atlantic, and mineral deposits of importance are limited in the main to the fringes of the great oceans and a few mountain ranges.

It is, however, possible to improve greatly the methods of mining and of concentration. To take the latter first, the enrichment of sands and crushed rocks by mechanical separation is as old as mining itself, but it has been greatly perfected in the last century, and the introduction of new physical methods, such as magnetic separation, froth flotation (depending on surface tension) and electrolysis have made possible the working of ores of low grade. Further inventions of this kind may revolutionise the extraction of minerals, and in that case the estimates of the life of deposits now accepted may be too pessimistic.

Improvements in mining may make it possible to extract a larger proportion of the useful material from a given deposit, and this seems particularly likely in the case of oil, but it must be remembered that mining operations are usually wasteful. The extraction of the rich ore from a mine frequently renders inaccessible a larger quantity of ore of lower grade which it does not pay to bring to the surface. Under the usual conditions of exploitation there is a natural tendency to 'skim the cream' from a deposit, extracting only that material which is immediately profitable, and this is most likely to occur where a concession is being worked, perhaps in a politically unstable country, by a foreign company. This is one of the factors to be taken into account in a scheme for an international control of raw materials.

Each new technological advance is apt to create a fresh demand for some material, which may be of scanty occurrence. The electrical industry is much dependent on the unique qualities of certain varieties of mica, and the engineering industries call for steels and other alloys containing the rarer elements, such as nickel, tungsten, molybdenum, cobalt and

vanadium. The light alloy industry is of very recent origin and has opened up great new fields of usefulness, and this again will in future make greater use of some of the rare elements. Little is known as to the available reserves of these metals, but the deposits containing them are usually small and are highly local. Some of them must be within measurable distance of exhaustion.

One possible mineral source as yet but little explored may be mentioned in passing. Owing to the disintegration of rocks by weathering and the transport of the products by water, all the elements present in the rocks are found in the sea. It is true that they are in an extremely dilute state, but recovery is not impossible. The fiasco of 'gold from sea water' of some years ago may seem to make this unlikely, but modern physical chemistry suggests possible means of concentration. Already magnesia is recovered from sea water in quite large quantities, the great volume of water which has to be handled not proving an obstacle.

Most minerals, once extracted from the earth, find application in industry, and after a period of usefulness which may be long or short become waste. Some of them, but not all, return in part in the form of scrap. Steel is made from pig iron, and until 1913 the world's production of pig iron was greater than that of steel, the balance being used in the foundry. In 1913 the curves crossed, and since then the production of steel has been greater, and increasingly so, than that of pig iron, owing to the very large quantities of scrap which are returned to the steel furnace. Not all of it comes back, corrosion and waste accounting for a considerable proportion. The use of recovered or 'secondary' metal, as it is called, is also becoming important in other metal industries, such as that of aluminium. Unfortunately, the rare key elements used in small quantities in alloy steels are largely lost, and it is here that a shortage is soonest likely to be experienced. Research is needed to devise means of recovering these essential and irreplaceable materials when the objects which contain them become scrap. The present salvage campaign is feeble in comparison with the drive in Germany before the war.

Much is now heard of substitutes for materials which have become scarce, and in Germany especially great efforts have been made to reduce to a minimum the quantities of metals, such as nickel and tin, which cannot be produced at home, but it cannot be said that any startling success has been obtained in this direction. The new field of plastics offers genuine substitutes for metals for a variety of purposes, and as some of them can be manufactured from agricultural products they represent a real contribution to the cause of conservation.

There is one instance of a mineral which has been almost entirely replaced by an artificial product. Chile nitrate, for long the only source of artificial nitrogenous fertilisers, and occurring only in certain rainless districts of South America, where it had been formed under quite exceptional geological conditions, was clearly limited in its reserves, and its exhaustion could be foreseen. In 1898 Sir William Crookes, in a famous address to this Association, painted an alarming picture of a decline in the supply of wheat owing to the exhaustion of soil nitrogen. Nitrogen compounds synthesised from the air have now replaced Chile nitrate, and the supply of them is inexhaustible. Radium, the ores of which are very rare, is being supplemented for medical and similar purposes by artificial radioactive elements, but substitutions of this kind are obviously very exceptional. In the main, we can only look to a more economical use of metals and to more complete recovery as a means of conservation.

Another fertiliser, phosphate, is mainly derived (apart from that which is a by-product of the basic steel industry) from a few sources of limited extent, and our present highly inefficient means of dealing with sewage leads to the greater part of the phosphates being discharged into the sea. This is a form of waste which is closely linked with the general question of the fertility of the soil, and the problem will call urgently for a scientific solution in the very near future.

The case for a planned conservation of mineral resources may not seem so strong as that for energetic action to conserve soils and forests. Even minerals of which the known reserves are small may last for several generations. The future of the rarer and increasingly important elements is more difficult to foresee because of the imperfect survey so far made of their scattered deposits, but it is likely that the demand for them will increase more rapidly than that for the more common minerals. However, many of the errors of the past have come from lack of foresight, and a planned world economy must take account of conditions a century or more hence, when our descendants may find themselves hampered by the wasteful exploitation of natural resources in our own day.

That an international control of raw materials will be needed after the war is a natural consequence of such a promise as that of equal access contained in the fourth aim of the Atlantic Charter. A recent issue of *Planning* has suggested a means by which such a control could be introduced, tentatively at first by application to a small number of commodities, the International Raw Materials Union of producers including representatives of governments in their capacity of consumers as well as producers. Such an authority would have many functions outside the scope of this paper, but as it would be in possession of the fullest information as to production, consumption and reserves it would be able to consider, in the light of that knowledge, the question of the possible exhaustion of reserves, and to recommend, or if its constitution should permit to enforce, greater economy in use or a restriction of exploitation.

Dr. L. E. Howlett
Canada's Optical Industry

IT has been suggested that I should make a few remarks to you about the establishment in Canada of an industry for the production of precision optical instruments in large quantities. In general, the history of the initiation of an industrial enterprise might not be of great interest to a meeting of this kind. However, this particular enterprise has an interest of its own because its

inception was the result of unusually successful co-operation between three important interests : government, research and industry.

It will be well recognised that the establishment of such a highly technical industry is not an easy task at any time. It becomes even more difficult when there has been no previous manufacturing experience of the sort in the country. Canada has never attempted to produce precision optical equipment either for peace-time needs or for military, naval and air operations. During the last war a limited amount of semi-precision optical parts was made for the simplest of optical instruments by commercial concerns ordinarily engaged in the making of ophthalmic lenses. It is probable that the quality of such work was barely good enough for the purposes for which it was intended.

Probably the earliest proposal to establish an optical instrument industry on a large scale was made about 1930. At that time Lt.-Gen. A. G. L. McNaughton was Chief of the Canadian General Staff. In that capacity he put forward to the Government a proposal for the establishment of a large arsenal which would concern itself with the manufacture of all kinds of munitions of war. The production of optical instruments would have occupied an important place in this undertaking. Unfortunately this scheme was not implemented at that time because of economic difficulties, and all active thought about it was in abeyance until the summer of 1939.

In 1939 General McNaughton, as President of the National Research Council, visited this country in company with representatives of the Canadian Manufacturers Association, to find out in what ways our industrial resources could be used most effectively in the war which at that time was clearly imminent. Information obtained during this visit provided General McNaughton with good reasons for again pressing that consideration be given to ways and means of creating a source of supply of optical instruments in Canada.

It was felt that the making of optical glass and the fabrication of this glass into precise optical parts and the carrying out of certain other technical operations, such as graticule-making, etc., would be of greater difficulty than the production of the precise metal parts required in optical instruments. The operations involved in making precise metal parts were more familiar to Canadian industries. For this reason the President of the National Research Council instructed the Optics Laboratory of that institution to make a careful survey of all the operations and techniques involved in the making of optical glass and the working of it into lenses and prisms. He also asked that as much information and experience as possible should be gathered on optical design and on special methods of testing optical instruments, particularly those for war-like purposes, and to obtain data about specialised types of testing equipment useful in production. To carry out the survey requested by the President, the officers of the Optics Laboratory made a careful study of instrument industries in the United States. In addition arrangements were made to secure the co-operation of the National Bureau of Standards at Washington. This institution had valuable experience in the development of the optical industry in the United States during the last war and has added to this experience continuously ever since. The officers of the Bureau of Standards placed all their experience at our disposal. Techniques were freely explained. Blue prints and other essential data on furnaces used for melting glass were also provided.

On the basis of this investigation a report was prepared assessing as accurately as possible the difficulties involved in establishing an optical industry. Recommendations were made as to the proper method of proceeding with the task in order to minimise these difficulties. The President of the National Research Council forwarded this report to the Government and decided that, pending a decision by the Government, the Council should undertake whatever preliminary steps were possible so that if the decision were favourable, much valuable groundwork might be accomplished which would result in a great saving of time later.

This policy among other things resulted in the establishment in the National Research Laboratories of a small optical shop for grinding and polishing lenses and prisms, where a limited personnel might be trained in the making of precision optics. A large amount of testing equipment which was lacking in the laboratory was ordered for early delivery. The time of the professional staff of the Optics Laboratory was largely devoted to the consideration of details which would be involved in the larger scheme.

During the succeeding months this preliminary work progressed rapidly, and by April 1940 several men were quite skilled in the making of precise optical parts. In fact, at that time all optical flats required by the National Research Council Munition Gauge Laboratory were being produced in this optical shop. These flats varied from 2 ins. to 12 ins. in diameter, the smaller being accurate to $\frac{1}{20}$ wave-length and the larger to $\frac{1}{4}$ wave-length. The replacement of lenses and prisms in damaged military equipment was being carried out successfully.

Early in May 1940 the Department of Munitions and Supply was finding it increasingly difficult to obtain supplies of optical instruments from the United States. Accordingly it was now considering very seriously the establishment of a source of supply in Canada. Discussions took place between the officers of the Department of National Defence, the Department of Munitions and Supply, and the National Research Council on the various aspects and requirements of such an undertaking. Further joint tours of inspection of American instrument factories were made. From the executives of these we received very complete co-operation in the supply of information.

Since it was now clear that in some form or other an optical instrument factory would be established, Dean C. J. Mackenzie, Acting President of the National Research Council, authorised a very considerable increase in the scope of preliminary work which had been initiated eight months earlier. This new work included detailed planning of melting furnaces and ancillary equipment for making glass. Tentative plans were prepared for the factory

lay-out, lists were made of necessary machine tools, optical grinding and polishing machinery, and the requisite scientific instruments for assembly and testing. It was felt that all this information would be of service, and save the time of those who would be ultimately charged with the responsibility of the production operation.

After consideration of various possible ways of administering the industry the Government decided that since it was in the main a production undertaking the responsibility for it should rest with the Department of Munitions and Supply, rather than with the Department of National Defence or the National Research Council. This department created a Government-owned company, Research Enterprises Ltd., to direct the undertaking. Such an arrangement was in line with the procedure which had been adopted for other specialised industries required for war production. Under the Minister of Munitions and Supply the executive body of this company is a Board of Directors. These were chosen from well-known and successful industrialists. Colonel W. E. Phillips, who has a high reputation in Canada for his ability as an organiser and administrator of technical industries, was made President of the company. This position is very important since it carries the active executive authority over the operations of the company. How happy was the choice of Colonel Phillips for this post has been proved by the way records have been broken in construction of buildings, the assembly of equipment and the general initiation of the enterprise. Although this company is completely separated from the National Research Council by the fact that it is included within the organisation of the Department of Munitions and Supply, the research and development facilities of the Council are always at its disposal when required.

It is interesting to note at this point that the company was also given the responsibility for the production of specialised radio equipment. The story of this phase of the undertaking is parallel to that of the optical phase, except that it involved the Radio Laboratory of the National Research Council instead of the Optics Laboratory.

I trust that this brief summary has succeeded in conveying to you some picture of how this large organisation, Research Enterprises Ltd., was made possible by the friendly and active co-operation of three important groups: government, research and industry. Perhaps we must confess that this co-operation was partly due to the urgent necessities of war, but nevertheless we should be pragmatic and draw satisfaction from the facts as they occur. Whatever the basis, the inception of this industry will serve as an example after the war of how to undertake the large peace-time developments which will then be necessary. If such co-operation is possible in the interests of destruction it should be equally and more logically possible in the interests of the improvement of the conditions of man.

Dr. G. D. Coumoulos

Personal Contacts in International Science

ANOTHER speaker this morning presented to this Conference the viewpoint of the younger generation of British scientists on the significance of personal contacts between the scientists of different countries in promoting international understanding and in stimulating scientific research. I shall deal with the same subject in the present paper. There is no actual difference in opinion but a different viewpoint. I see the same subject from another angle. I belong to a small nation—Greece—and therefore my experience is of the man who is at the other end of this mutual understanding at which we both aim.

Science, that is to say the knowledge of nature, may be a social function of a society or may be developed for the entertainment of a scientist. There are two extreme views on the function of science. Nevertheless, its progressive development will always depend on how much scientists are conscious of these aims. But these individual scientists are members of greater social units, and when we regard here science as an international concern, these units must be the nations. The internationalism of an idea cannot be understood without the pre-existence of this idea in the nations. I regard the nation, at the present stage of social evolution, as the greatest and at the same time the smallest unit of human societies. Therefore we must accept the existence of separate national groups of scientists. The Prime Minister of this country, Mr. Winston Churchill, says in his message to this Conference that he looks forward to scientists of every nation devoting all their energies to the common task of repairing the trail of material and moral havoc which the Germans leave behind them.

So science, this specialised function of the human beings, is exercised by individual scientists who belong to separate nations but have the same aims: (1) to forecast the changes in the surrounding Nature, and (2) to exploit and even change Nature's processes for the benefit of the larger society of human beings. That is how science is from the outset an international concern. We all understand that this in reality holds only for those scientific discoveries which are not of immediate practical application, while when this knowledge is associated with practical applications it is guarded either as a private secret or a secret of a certain group. In this paper I am thinking of that science which is taught in the universities and is open to discussion in the learned societies and the special periodicals of the different nations. An international understanding for this science already exists, but is not based always on a mutual basis. This scientific research has some special national characteristics, which, not being absolutely exclusive and permanent, have rather historical and traditional reasons for their existence. The social needs and the economic development determine the grade of evolution of science for each nation. But there are also other reasons, those of national character, which explain why certain problems are taken up and solved in a certain way. This stands only for the theoretical achievements of science. These characteristics in scientific research are not obstacles to international understanding when they are considered as mere research methods. The personal contacts of the scientists of the different nations will help to bring about a better understanding

of these national characteristics and to build friendly ties between them. There will be not only an exchange of experience but (what is more important) these friendly ties will in the future double their interest in following every scientific research that is done in any country. Sometimes we prefer to make reference to papers by people we know rather than to papers by people with whom we have no tie independently of their actual value. Thus, as it happens to us to know more scientists of particular nationalities, it becomes obvious that this preference goes only to the achievements of those national groups of scientists. For the development of science the publication of papers is not enough. To an extent larger than is realised the transference of scientific ideas from one set of scientists to another is effected by means of visits and personal contacts. In many cases some new ideas do not spread beyond the laboratory of their origin because a scientific background which is necessary has not been established yet. But the interplay of such ideas from different sources will help scientific research. This occurs only when scientists who have absorbed the same set of ideas in different centres happen to come together. Almost every visit of a scientist from one laboratory to his colleagues in another results in the introduction of a new piece of information or point of view that no amount of reading would have managed to effect. There are techniques which are impossible to transmit without visual demonstrations, and ideas too intangible to be put into writing, yet capable of communication by personal contact.

Every effort must be made to facilitate these visits of the scientists of one nation with another. This must not be limited only to scientists holding offices but must be organised on a national scale.

Another speaker this morning suggested an International Society for Scientific Research which would help this organisation. With this background in mind permit me to give you my experience from my own country, Greece. She is a small country with a small industry, a few decades old. This industry, which has not developed organically as it is not based on the country's natural resources, has thus not created a scientific circle of its own. Economically and diplomatically Greece depends on larger nations or groups of nations. In the same way the Greek scientists have fairly close relations with all prominent scientific circles—that is to say the Anglo-American, the German, the French, and the now rising Soviet science. These circles belong to highly industrialised States and have characters of their own: (1) their language, (2) specific characteristics depending on historical, social and academic considerations, and (3) their philosophical background. Only dialectical materialism on which Soviet science is founded is claimed to be by its nature of an international character. Neither English nor French science has a definite general theory as a background. When German science under the Nazi influence adopted mystical theories for its nationalistic character, it lost a good deal of its prestige.

The Greek scientists are not influenced by these national characters of each scientific circle, but use the mere scientific facts for further research and adaptation to their own surroundings. Foreign languages do not constitute a barrier as they use foreign publications for scientific information and for publishing their own papers of general importance. The scientists of small nations have to deal with the problems of their own countries which the more progressive scientific circles have already surpassed, so that they have not many opportunities to become known. On the other hand it is difficult for them to work out the theoretical problems which they follow in the scientific publications; because in a small nation there is always only a small proportion of scientists preoccupied with these problems, and they would be too few to be able to create the necessary environment and atmosphere for such a study. In all cases in which those same people remained abroad they became first-rate scientists. Under the same conditions scientists, no matter of what nationality, would develop similarly. All these manifestations are evidence to show the existence of vast possibilities for progress in scientific research on an international scale. But the most important requirement for this development must be the existence of an understanding of mutual character. Whenever a more progressive scientific circle thinks of the scientific groups of small nations as if they were inferior, then there can be no understanding. Until now except for a few congresses which were held in Greece we had only a few foreign scientific missions, which, however, did not achieve marked success. This might have been expected, since social and economic development mainly determines the grade of scientific evolution, and a higher grade cannot be grafted on but can only be reached organically. The smaller nations ask for a co-operation to accelerate this evolution. A sincere international understanding with more far-reaching results will be brought about when each nation when collaborating in the common cause of science for the benefit of human society is able freely to develop its own potentialities.

Here I must mention the 'Cultural Convention' signed by this country and my country. It was inspired by the British Council and is based on an understanding of a mutual character. It aims at providing increased facilities for the personal contact of the scientists of both countries. This Convention, when it becomes a reality, will prove to be the first serious official attempt to organise this sort of understanding on a national scale. Individual scientists are always ready to collaborate in such aims.

I see in this Conference the dawn of a hope that this will of the scientists may be organised on a world scale.

Mr. E. G. Couzens and Dr. V. E. Yarsley
Plastics as a Medium for the Future

In view of the widespread misconception which still appears to exist about plastics and the plastics industries, it may be helpful if we preface our observations with a brief restatement of the nature and functions of plastics.

Plastic materials comprise a large number of high molecular weight organic compounds of many different chemical types and families, which in addition to the element carbon have in common the fact that they are built up of long chain aggregates. This structure accounts for many of the

peculiarly attractive properties which characterise these modern materials of construction. Accordingly, as these long chains have mobility relative to one another or have been rendered rigid by cross linking, we differentiate between the two broad classes of plastics, those which are thermoplastic and those which are thermosetting.

These long chain compounds are obtained either by treating naturally occurring materials which have the desired chain structure such as cellulose or casein, or by building up from simple units by the chemical processes of condensation and polymerisation. Since the pioneer plastic celluloid was first produced over seventy years ago, many long chain materials have been produced on a commercial scale, but it was in the period following the World War of 1914 to 1918 that the major developments took place which laid the foundation of the plastics industries as we know them to-day. Since that time new plastics have come into production, particularly the vinyls, but a fuller appreciation of the properties of both old and new have led to a much wider total use, each tending to develop its own field through application of its special properties.

During this period many of the earlier prejudices which grew up round the new materials have been rooted out, but there still remains the feeling in the minds of many that plastics are cheap substitutes for the conventional materials of construction. As products of chemical synthesis plastics can most certainly be classified as synthetic, but they must certainly not be thought of as substitutes. It is rather as 'advantageous alternatives' that they should be regarded. Public recognition of this point of view is of the greatest importance. Its acceptance in the past would have prevented much nonsense being written and spoken about the inferiority of German ersatz materials and may have an important influence on plastics as a medium for the future.

With certain exceptions the plastics industry had no previous experience of the problems of war production. Nothing comparable to the German-planned development of plastics had taken place in this country and efforts of the industry to interest aircraft manufacturers, for example, were of little avail. The production of acetylene, vital to certain plastics, was a matter of no interest to Parliament, and when the war began, materials of essential importance had to be imported and the most vigorous action on the part of individual concerns has been required to save the situation.

At the outbreak of the war the potentially great forces of the plastics industries were scattered, latent but in many cases untried. The war focussed these forces on the national effort and these modern materials of construction were at length given an opportunity to show their worth in the present emergency.

The importance attached to the new industries is evidenced by the fact that an independent Control for Plastics was established by the Ministry of Supply, which in common with other ministries have on their staff men who have served admirably as liaison officers between the industry and the Services.

Thus plastics have come to rank with our older major industries in the war effort, and in a short time these young industries, many of which had had such a hard fight in their infancy in this country against the conventional ideas of the last century, have sprung into established maturity. Such a development must inevitably have come, but the war certainly accelerated it in this country by many years. The nett result has been that forces which were working separately are now united to make the maximum use of plastics to serve the nation's need, and what has happened here is happening or has already happened in the other great plastics-producing countries of the world. What this actually means to-day in terms of hard service will only be known after the war, when it will be permissible to record the many rôles plastics have played. What it may mean for the future of our world, and in particular for the reconstruction period which must follow the present upheaval, we cannot yet accurately appraise, but what we can see makes it certain that it will be no empty phrase when we say that the Plastics Age is dawning.

The strenuous needs of the war have united the plastics industries here as nothing else could have done. New materials have been developed or perfected, and production methods have in many cases been completely revolutionised. Thus out of evil has come this good, that materials and processes have been made available which, if wisely guided. should serve the peaceful needs of mankind and materially aid him in the gigantic task of reconstruction which will face him in the post-war period. Exactly how war needs have accelerated the developments of plastics cannot now be disclosed, beyond a few instances in general terms. The wide use of plastic sheet for aircraft may well have laid the foundation of what may grow to a large industry—the manipulation of plastic sheet. Transparent plastic for aircraft screens and the like has made possible designs which could not otherwise have been contemplated ; while the use of plastics instead of metals has developed a remarkable technique of manipulation impossible with the metals themselves. The methods thus developed for the production of fittings and units for aircraft should be capable of wide application in the fabrication of articles for domestic use.

The exacting demands of the aircraft industry for light yet strong materials have given a new impetus to the production of impregnated and laminated plastics. New synthetic resinoids have been developed for adhesives which have revolutionised the manufacture of plywood and veneers. Synthetic materials have also completely changed the technique in the manufacture of varnishes and coating compositions, and have made possible surface finishes which combine excellent appearance with remarkable durability.

The production of low-density materials, in which plastics play a part and which provide a rigidity-weight ratio far in excess of anything metals can show, has the most fascinating possibilities. It is still in its infancy, but is already of profound interest to aero-engineers.

In these and many other directions the advent of war needs has accelerated development in the plastics industries. These constructional materials which science has made available are at the present time being used in the production of engines of war, but all the experience thus gained, unique experience which might never have been

gained in the course of normal life, should be capitalised in the post-war period and used for the service of mankind instead of his destruction. The present crisis has in many instances given plastics the trial they might never have received, necessity has torn aside convention, prejudice and vested interest. Much of the experience thus gained will have been dearly paid for in terms of human suffering, so that it is up to those who plan the reconstruction to see that it gives the maximum service to mankind in future.

Even whilst the smoke of battle persists we may turn our attention to the problems which must arise when the sword is beaten into the ploughshare and reconstruction begins.

It has been suggested that plastics should be considered as ' advantageous alternatives.' To do this adequately their properties must be discussed in comparison with those of the older materials of construction.

The ideal plastic is a tough material with high softening point and high modulus of elasticity. But metals have these properties, so that it may be asked, 'What are the advantages of plastics?' They soften at temperatures low enough for easy manipulation but high enough to maintain rigidity at working temperatures. They are transparent, like glass, but not brittle. They are light like wood, but have no grain and can be cemented; they are coloured, and non-corrodible like ceramics, but tough; they can be highly elastic like rubber, but stable in the atmosphere and do not require vulcanisation; they can be like leather, but are rot-proof and practically indestructible—in fact they compete with almost everything except the heavier materials of construction.

Therefore there will be the severest struggle between plastics and these older materials, a struggle in which the potentialities of each substance will be exploited to the utmost and to the great advantage of the user, who will get all the advantages of the new materials and find hitherto unexpected possibilities in the old.

In addition it must be remembered that plastics are essentially the materials of mass production, and it is most certainly these methods which must be applied to meet the post-war needs. Furniture and household effects, houses and their fittings, ships, aircraft and motor cars will be required in vast numbers, and in the production of these plastics will play an important part. Already architects are designing window-frames, architraves, doors, and furniture out of new types of thermoplastic laminated wood, in which a hitherto undreamed of simplicity of construction will be exploited. A whole new industry is appearing based on the impregnation of pulp preforms with synthetic resin, producing very large mouldings suitable even for motor-car panels, practically impossible to dent and of great strength and lightness. The injection moulding machine is injecting pounds instead of ounces, and extrusion machines are thrusting out both soft and rigid sections at rates exceeding those possible with rubber and metals.

Meanwhile physicists are concentrating on the important task of determining the physical properties of plastics for direct comparison with those of other materials, and specifications which are the lifeblood of mass-production are being laid down to control properties that have hitherto been ill-defined and haphazard.

And if further evidence is needed of the significance of plastics, consider that in America plastics is becoming ' big business.' The famous Bakelite Corporation has become a unit of the Carbide and Carbon Corporation, already manufacturers on a large scale of vinyls; Plaskon has been taken over by the Owens-Libbey-Corning Corporation, and Shawinigan and Monsanto are linked in a great plastic organisation.

The widespread use of plastics will affect the lives of people beyond the mere enjoyment of the use of scientifically produced units in our daily life; it will most certainly have a profound effect on national and international relationships. The manufacture of plastics is independent of climatic limitations, and its raw materials are frequently indigenous and will become increasingly more so, so that the wealth of a nation may no longer be governed by the weight of its mineral deposits. In these respects the plastics industry is essentially ' foot-loose ' in Prof. Sargant Florence's phrase. A nation's wealth has been shown to lie in the ability and work capacity of her people. How this can be expressed through the medium of plastics only the future can show; it can, however, be said with certainty that the potentialities are such as they have never been at any age.

Whilst much has been achieved much remains to be done. There has been no plan for plastics; in the nature of things there could not have been. We have of necessity produced one material after another and tried to apply it. In this process a vast amount of information has been collected, as is evidenced by the volume of patent and technical literature now relating to plastics in all the major countries of the world. That line of work has served its purpose and achieved much good, but we now know that rather than produce a material and then find a use for it, often in the face of prejudice and competition, it is better to develop a material to meet a specific need. This is the logical, the scientific path along which co-ordinated development in plastics must in future work. As Carleton Ellis so aptly put it, we ' must tailor the long molecules ' to our purpose.

Plastics will bring new products and new standards of hygiene and colour into the life of everyone, and corrosion and decay, to which we have long been accustomed with the conventional materials, will be reduced to a minimum. New types of architectural materials can speed up production and the exploitation of the remarkable properties of plastic products should give rise to new methods of construction.

It is the task of the public to understand the nature and properties of plastics, of industry to attract the best minds to the exploitation of their products, and of the Government to continue and extend the research it is already doing, and to undertake long-term investigations, the results of which will be available to all. Only so will the full possibilities of plastics be realised when reconstruction begins.

Dr. C. H. Waddington
Technical Advances in Biology

BIOLOGY impinges on social affairs in two main fields: in human biology, of which medicine is only

a part, and in food production. I shall not attempt to discuss the first of these fields in any detail. But it may be doubted whether new technical advances have nearly such a large part to play in it as has the application of already existing knowledge. Perhaps the major medical problem —and it will be enormously aggravated in the post-war world—is the attainment in practice of optimal standards. Sir John Orr has pointed out that we can already define an optimal standard in nutrition, and that even in times of peace the majority of the human race do not attain it. Mr. Herbert Morrison mentioned other standards, of clothing, housing, etc., and I was surprised that he did not add industrial hygiene.

Closely connected with this is the second major problem of human biology, that of reversing the general fall in the reproductive rate of industrial populations.

The third major problem is the conquest of tropical diseases. This will certainly call for many advances in detailed information, but probably these will for the most part lie in directions which have already been laid down. The campaigns of the Rockefeller Foundation against the mosquito *Anopheles gambiae* in Brazil and against yellow fever in the Sudan are striking examples of what can be done by the organised application of what we already know.

The advance of human biology is therefore likely to depend more on advances in administrative and political technique than on the discovery of new laboratory methods.

Turning now to the second major biological field, that of food production, I cannot go into details about what may be called the normal gradual development of agricultural technique, such as the greater use of silage and the adoption of the ley system of farming. But there are certain radically new uses of crops which may have a more profoundly disturbing effect on agricultural practice. The use of straw as a feeding stuff for cattle, after suitable chemical treatment, is one such development. More important, if it passes into large-scale practice, would be the direct use of grass for human food. Grass is much the largest crop in this and many other countries. We normally use it at second-hand, after it has been converted into milk or beef or mutton. The conversion process carried out by our domesticated animals is always of rather low efficiency. Some success has already been achieved in extracting the food substances directly in a form suitable for human consumption, and there is no reason why all the technical difficulties should not be solved in a very short time. Again, profound changes may be produced by the method of growing yeasts, which are very valuable food material, on farm wastes together with synthetic nitrogen from the air.

The use of mechanical aids in handling crops will certainly increase, but we must also expect an increase in what one might call biological engineering. The sterilisation of soil and the use of culture solutions are both methods of ensuring greater uniformity in cultural conditions. The former is rapidly spreading, and it is difficult to believe that the last word has been said about tank agriculture ; standardisation of the technique, and its improvement, perhaps by the employment of extra lighting, are almost certain to make it a more practical proposition than it is at the present early stage. The controlled application of plant growth hormones is also only just passing out of the laboratory into the field. So far its main application has been in connection with the rooting of cuttings, but recent results suggest that we are on the verge of discovering a number of new hormones affecting the growth of particular organs and the initiation of particular processes, such as flowering and the setting of fruit. If these investigations progress as one may hope, a completely new technical weapon will be placed in the hands of the grower.

The duration of the various phases of a plant's growth can also be affected by treatments involving controlled lighting and temperature. Botanists already have considerable insight into the physiological bases of the differences between ' long and short day ' plants, between spring and winter forms of cereals and between annual and biennial races. The leading part in the development of these subjects has been taken by Soviet scientists, who have concentrated particularly on the effects, on the subsequent development of a plant, of treatments given to the seeds before planting. This technique, known as vernalisation, was applied to large-scale practice by Lyssenko, and millions of acres have already been sown with vernalised seeds. The Russians claim that the results are so beneficial as to revolutionise agriculture in some parts of the Soviet Union. I understand that English opinion is not yet entirely satisfied as to the validity of all these claims, and that our experimentalists have not as yet been able to obtain such striking results. But there seems little doubt the physiological basis for vernalisation is perfectly real, and that some important applications of the method are likely to pass into technical practice.

Striking developments may also be awaited from the further application of new methods of plant breeding. The breeding of disease-resistant varieties, which, for instance, trebled the yield of Louisiana sugar cane between 1926 and 1929, will probably score some new successes ; but it cannot be considered a new technical advance. On the other hand, the employment of hybrid vigour by the use of crossbred seed is a development of the last few years in maize cultivation. It has led to increases in yield averaging about 20 per cent. in that crop, and has probably got similar benefits to offer in certain other fields ; the John Innes Institute at Merton has prepared hybrid tomato seed with considerably enhanced productivity.

The spectacular advances in plant breeding are likely to come from two fields which have only recently been intensively investigated. The first is the study of the wealth of forms available in nature for our use. As Vavilov pointed out, in the regions where our crop plants originated there are almost untold numbers of related varieties existing in nature or in primitive cultivation. Special expeditions have recently been sent out, from many different nations, to collect these. The wealth of new material placed at the disposal of the breeder can be seen from a single example, All the cultivated potatoes of the Old World derive from a single species, and probably from a very few individuals. We now know at least thirty species,

forming a polyploid series, all of which are thought worthy of cultivation by some tribe in South America. They include both frost-resistant and short-day forms ; it is not too much to hope that from the former we shall develop strains suitable for the Arctic, and from the latter varieties which will form tubers in the Tropics. The profound results of such a spread of the potato belt do not need to be emphasised. A similar, almost embarrassing, wealth of new material is available for breeders of other crops. We have scarcely an inkling, from a genetic point of view, of the varieties of tropical crops. A thorough survey of the genetic make-up of plants of economic value in the colonial areas is likely to repay its cost many hundred times when the development of the Tropics is seriously undertaken.

The second major source of new varieties may be found in the very recent technique of artificially doubling the number of chromosomes in hybrids, thus rendering them fertile and comparatively stable in hereditary characteristics. Nearly all our most important crop plants are polyploids which have arisen by the chance occurrence of a similar process in nature. It is inconceivable that the organised application of the method will not produce entirely new species of plants of great economic importance. It is too early yet to name with confidence any instances of such innovations, but the promising wheat-rye hybrid is an example of the kind of thing with which we may expect to be presented.

In the animal field, it does not appear that there are so many spectacular advances to be expected in the immediate future. Hammond's demonstration of the differential effects of the level of feeding at different stages of growth will probably lead to important technical advances, but these do not seem likely to cause any great disturbance of the normal system of stock-keeping. The most important new technique which is at present passing into general practice is probably the method of artificial insemination, which already makes it possible to use the sperm of a tested male on some hundreds of times more females than would normally be the case. Poor stock may thus be fairly rapidly improved.

The method has an enormous potential importance for the immediate post-war reconstruction of the devastated areas of Europe. Over the Continent as a whole, and in this country as well, flocks and herds of all kinds of domestic animals are being drastically reduced in numbers. One of the first tasks in restoring the productive capacity of European agriculture will be the rapid increase of those animals which remain. This should not be left under the control of the uneducated farmer or to the blind operation of economic forces. An unparalleled opportunity will be presented for bringing about an important improvement in the general level of genetic quality in European stock. But it will only be possible to make use of this opportunity if, during the war, the preliminary staff work is done to mount an offensive on the reproductive front. We should, when the war ends, have arrangements already made for mobilising supplies of first-class male germ-plasm and an organisation capable of shipping it to the regions, both in England and on the Continent, where the multiplication of herds is proceeding. It is fortunate that some of the worst devastated countries, such as Poland and parts of Russia, had already made considerable progress in the practical use of the technique of artificial insemination, so that it is not too much to hope that executives could be found willing and able to accept supplies of superior sperm and to put them to good use.

Similar considerations apply to the problem of European crops. It is probable that the normal sources of supply of first-class seeds will be disturbed if not destroyed. In England this problem has already arisen, since in normal times we obtain many of our vegetable seeds from foreign sources to which we now have no access. If the war continues much longer, the production in this country of good seed will have to receive more serious consideration than it has up to the present. If any organisation is set up to deal with this wartime problem, it should also be capable of expansion to cope with the post-war reconstruction.

I cannot forbear at this point from making some remarks which may seem to some a digression from my main theme of technological advances, although to my mind they are a legitimate part of it. However narrowly one may wish to think of biological technology, I do not see how one can altogether neglect the political technique by which alone biological methods can be put into practice. Professor Hill, in the opening session, suggested that it is not the business of scientists to consider such questions. He again asserted his agreement with Hooke, who advised us not to meddle with morals or politics. I venture to put forward the opposite view. Hooke's advice appears to me to be not only mistaken in intent but impossible to carry out. Science does, whether it wishes to or not, meddle with morals and politics. It is arguable that the invention of the internal combustion engine and the development of the car has had a greater effect on ' morals ' (in the narrowest sense) during the last fifty years than all the sermons preached in all the churches. Consider another technical development which appears to be just round the corner, the separation of male-determining from female-determining sperm, which would make it possible to choose the sex of offspring. This might, of course, revolutionise the dairy and poultry industries. But think also of its implications in human affairs ; this would be meddling with a vengeance !

May I return to the example of the T.V.A., the largest instance of scientific planning carried out in a non-socialist economy such as our own. Professor Gulick described to us the use which was made of scientific methods of stating the problems and of scientific techniques in solving them. I could wish we had heard more of the part, if any, of scientists in bringing the whole project into existence. One has read of the ferocious legal battles by which it was defended. One knows that similar political genius, and similar battles fought and won, will be required to put into effect many of science's technological discoveries—not perhaps the particular one of herd improvement which I mentioned above, but certainly many others. I think many scientists as well as myself are anxious to understand our way about this aspect of our technical problem.

Let me return now to more strictly biological

techniques. I was speaking of methods of increasing the number of offspring obtained from a valuable male. It would be almost equally important if we could increase the reproductive efficiency of valuable females. Suitable hormone treatment has been shown to induce ovulation in many animals, and the method has already been applied to sheep and seems likely to enable us regularly to obtain two crops of lambs instead of one. It is also possible to induce the shedding of abnormally large numbers of ova. In the rabbit these can be introduced into the uteri of other females, where they undergo normal development. If this technique can be applied to other animals, we should have the desired method of obtaining a large number of offspring from a given mother. While this is not likely to play a part in ordinary animal husbandry, it might be of the greatest importance in establishments devoted to the breeding of stock.

Hormonal treatments may also profoundly influence other branches of stock-raising. We now have some control over both the quantity and the chemical constitution of milk. As Sir John Orr has pointed out, this will for long remain one of the most important foodstuffs, and our new methods of control over it may be of the greatest importance. Hormonal methods of controlling size are more in dispute, and I shall do no more than mention them as a potential dark horse.

The application of the last few methods lies some years in the future. Perhaps the most important technical advance which we should strive for in the immediate future lies in the sphere of organisation. Professor A. V. Hill spoke of the need for bringing academic scientists and official scientists closer together. A thorough reorganisation of biology is capable of producing much more important effects than any single technical advance. But I should urge that if reorganisation is to be undertaken it must cover the whole field. The aspect of biology which I am primarily referring to when I say this is the educational system, from the elementary school level to the university. At present biological education is still dominated by interests which were in the forefront of social life some hundred years ago, when we were engaged in the discovery and classification of the resources of the living world. It has in recent years been partly revivified by the injection of physiological ideas ultimately related to medicine. Ideas derived from regarding animals and plants as productive systems do not yet play a nearly large enough part in it, and biologists will not be able to play their full part in social life until their attention is more systematically directed into socially important directions.

At the same time, the fault is by no means all on one side. Professor Bernal gave us a classification of the ways in which science could, and should, be incorporated into the general practice of government. It was very clear that the government laboratories do not at present exercise all the functions which he suggested. The problem is not only to devise a method of submitting academic biologists to a course of applied research, but also of allowing pure scientists to have more influence in indicating the fields to which scientific methods should be applied.

This double problem will not be at all easy to solve, and will require the collection and consideration of a great body of data about the present biological curricula, the activities of academic and applied research institutes and their relations with one another. Moreover, many of those whose advice would be most valuable are engaged on more pressing forms of service. But at the same time, just because of the inadequate organisation of biology in the past, there are quite a large number of biologists whose time is not yet fully devoted to important social service. I should urge the desirability of considering whether a committee should be set up, even in war-time, to accumulate the necessary data and at any rate make a preliminary survey of the problems involved. For the problem of its own organisation is in many ways the most important technical problem which biology has to tackle.

In conclusion, then, I should like to emphasise the two immediate steps which have emerged. The first is the setting up of a committee to organise the scientific restocking of devastated areas. The second is the formation of a committee to consider the whole organisation of biology in its function of one of the activities by which society maintains and develops itself.

Dr. G. Lewi, Dr. O. Eisler and Dr. J. Cisar
Problems of the Technology of Unutilised or Insufficiently Utilised Raw Materials and Waste Products (Abstract)

One of the implications of the exhaustion of some raw materials, brought much nearer by the insane wastage of valuable materials in this war, is the discovery of new methods to enable us to utilise raw materials which for various reasons have not been sufficiently exploited, and the insistence upon a more rational use of raw materials which are at present being used too wastefully.

Examples bringing out the full meaning of the first part of this contention are: fixation of nitrogen from air has been accomplished; other raw materials almost as easily accessible as air, namely, clay and sea water, are still waiting to be used, perhaps in the first place as a source of production of light metals; large quantities of $MgCl_2$, which at present remains a little-used waste-product in the manufacture of potash, should furnish a rich source of raw material for the manufacture of magnesium. New possibilities of utilising wood are indicated.

By a more rational use of the existing raw materials is meant such use as will entail minimum wastage. This implies two things: (1) to seek the best and most efficient methods of processing, leaving as few waste products as possible, and (2) to seek new methods of further optimum utilisation of unavoidable by-products or 'waste' products. Avoidance of waste in the use of the fundamental raw material—coal—was discussed in some detail, and new possibilities were shown of utilising some by-products of gas manufacture, e.g. naphthalene for production of the increasingly important carbon-black. Should an international authority be established to deal with the control and conservation of primary raw materials it should also be empowered to make any improvement or discovery of new methods in a more economical exploitation of raw materials or waste products available for general use.

In conclusion, attention was drawn to the problem of restoring harmony between the production and consumption of natural raw materials and of their synthetic, artificially produced substitutes. Although the more extensive production of these materials was occasioned by the needs and circumstances of the war, most of them will continue to preserve a lasting place in world economy ; the problem is where and how they should be used so that their use may increase human well-being and not cause needless misery to lands and peoples living on the production and utilisation of the natural raw materials.

Mr. R. Fitzmaurice
Science and Technological Advance applied to Building

It has often been said that building lags behind other industries in the extent to which it makes use of modern scientific developments. There is some truth in this, and a number of factors account for it, not all of which are under the control of the building industry itself. Nevertheless, there has been a great deal of scientific work applied to building problems in the last twenty years, and a quite considerable record of achievement. This work has been carried out in many laboratories in different parts of the world, and there has been free interchange of ideas and publications bewteen the scientific workers in different countries. Though the basic human requirements are broadly the same in all countries, differences in way of living and climate tend to make the various countries adopt different solutions of their common problems.

By way of illustration of what science can do for building technology the following subjects may be examined : acoustics of buildings, heating and ventilation of buildings, daylight illumination, and the exclusion of damp from buildings.

Very great progress has been achieved in acoustics of buildings. The design of auditoria has been brought to the stage where a reasonably precise estimate can be made of the listening conditions in any proposed auditorium. The present satisfactory state of the art is founded on the pioneer researches of Sabine in America ; contributions have been made by workers at the National Physical Laboratory, and an interesting line of study was under investigation at Berlin shortly before the war, on the absorption of sound by resonant panels, the completion of which would have added notably to the treatment of auditorium acoustics. It is true to state that knowledge has reached a point such that no auditorium need ever again be built in which speech is unintelligible. Refinements are in progress which should enable us to design concert halls so that the finer tone values of all the instruments in an orchestra are heard to the best advantage.

Knowledge of the mechanism of sound transmission in buildings has advanced enormously in recent years. The Building Research Station working in association with the National Physical Laboratory claims the credit of being the first in this field to publish a comprehensive treatise on the treatment of sound insulation in the design of buildings. The forward step in this case was made when it was recognised that sound transmission required investigation in terms of walls, partitions and floors acting in association, i.e. sound transmission in the complete building, and that isolated tests on the individual components were not alone sufficient to yield the answer to the practical building problem. The next-door wireless in semi-detached and terraced houses, or in flats, need no longer be a source of annoyance, and the relatively small cost of providing the necessary insulation is considered by a builder who has tried it out to be a very good investment. It has been not uncommon in the past for buildings to prove very inconvenient in use on account of street noises. On very noisy thoroughfares conversation in offices becomes difficult and the disturbing conditions in, say, hospital wards are very bad. It is now possible to predict the performance of various structural combinations and to estimate the noise reasonably accurately. Consequently there is no reason why these defects should be found in new buildings.

Much scientific work has been done on heating and ventilation, and the mounting cost of fuel makes it ever more important to conserve heat wherever possible. The main lines of investigation have been in the direction of determining heat losses through various kinds of building structure in order to provide working data for the architect and heating engineer. Progress has also been made on the means of defining and measuring comfort conditions, a necessary criterion when the efficiency of heating appliances is being examined. As a side line in these investigations the smoky chimney has been investigated and, here again, a solution has been found which works well in practice. It is of interest to note that the main point of the work was to check the validity in terms of modern construction of recommendations made by Rumford in his essay on Chimney Fireplaces published in 1796.

Blackout conditions in wartime have focussed attention on the need for obtaining the maximum efficiency from such windows as are left to us. Simple methods of predicting the daylighting efficiency of various arrangements of windows have been developed and these should soon be a normal part of the equipment of any architect's office. When a simple method of predicting efficiency for any design has been worked out it is not usually very long before the main principles of application can be enunciated.

Dampness in buildings has long been a source of ill-health and, especially in old buildings, damp corners and damp cupboards have come to be regarded as commonplaces. The principles underlying the transfer of water in porous materials have been elucidated, as have also the physical phenomena causing cracks to form in buildings, and there is now a sound basis for design so that it should now be just as discreditable for a building to be damp as for it to fall down. Mycologists working at the Forest Products Research Laboratory of the Department of Scientific and Industrial Research have determined what are the precise conditions of dampness under which the various forms of wood-destroying fungi are active, and many of the past mistakes leading to premature destruction of floors and stairs can now be avoided.

It is one thing for scientific investigation to

elucidate the underlying principles and to give broad indications of the lines on which technical developments can be based. Their application to the practical building conditions is another and more difficult problem. The first obstacle arises from the lack of scientific training amongst workers in the building industry. This applies to architects, builders, craftsmen, and surveyors alike. The practical work of building is still largely governed by tradition. Research in recent years has, in a number of directions, gone some distance towards formulating, in precise scientific terms, principles which would free the industry from the fetters of mere tradition. It is clear, however, that the full utilisation of the new knowledge must presuppose fuller scientific training than was necessary in the past for those engaged in the practice of the industry. It is also necessary for ensuring the full co-operation which is so essential between the research worker and the practical man in working out further advance. The one cannot do without the other ; each must learn the other's language. In the manufacturing side of the industry there is a considerable disparity in the extent to which trained scientific workers are employed. Some groups, making products for other industries as well as for building, have large scientific organisations and contribute materially to the general advancement of knowledge. Other groups, with corresponding resources, attempt comparatively little on the scientific side. The products of the groups with scientific organisation behind them have, however, to be applied to the building by a constructional industry which for this reason again needs a scientific outlook. The need is being realised and a sub-committee of the Architectural Science Board, Royal Institute of British Architects, is reviewing the field of science in architectural education and has recently published its first report. The adoption of the recommendations laid down in this report will clear the way for much wider application of the resources of science to building, and it is hoped that other sections of the industry will follow suit in the near future, and so make possible a stride forward in technological development in the industry. The scientific worker stands rather outside the industry at the moment, benevolent but aloof, and more rapid progress would follow his adoption as a working partner.

Another factor which prejudices advances in building technique is the framework of regulations governing building. In recent years there have been revisions of regulations leading to more scientific approach, but broadly speaking the regulations are still framed in such a way as to have the effect of impeding the adoption of new and well-tried ideas, and tend to stereotype conventional forms. Ideally, the regulations should state the purpose aimed at rather than the means by which they must be satisfied. Notwithstanding the advances in recent years, however, it would be misleading to suggest that all the requirements of building can now be stated in precise scientific terms. Until this is possible and regulations amended accordingly the way is barred to any rapid technological advance. It is an encouraging sign that many groups within the industry are focussing attention to the state of building regulations. In view of the great volume of work confronting the industry it is of the first importance that labour and material should be used with the utmost efficiency. The application of science has promoted efficiency in other industries, and it would indeed be surprising if it did not produce similar results in building.

Prof. J. H. de Boer
Industrial Research and the Universities

I SHOULD like to say a few words as representative of the Netherlands Government in London, and of the few Dutch scientists who succeeded in coming over to this country, to express their very good wishes to this Conference.

As you know, science in Holland has always been on a rather high level. The Dutch scientific world has always tried to promote international scientific relationships. Perhaps many of you will remember that after the last war it was the Dutch scientists who brought together again the scientists of all countries. Another thing was that many excursions to foreign countries were arranged of scientists and students, and especially to Czecho-Slovakia. One of my colleagues who is present, and myself, can state from experience that those excursions to Czecho-Slovakia were a big success. Let us hope that after the present war there will be very close co-operation again between all scientists who are free now and the scientists who are in enemy occupied territories.

Originally industry contributed more to science than science to industry. In modern times industry derives great benefits from science, but there is still a beneficial influence of industry on science because industry inspires to further research, not only technical but also purely scientific. In order to promote this interchange between science and industry, namely, the application of new scientific discoveries and methods to industry and the furtherance of research by inspiration from industry, a very close collaboration between scientists and all those who are concerned in the applications of science is necessary.

There is, of course, a close collaboration between research workers and technical workers in the big research laboratories of a few of the great industrial concerns in the world, and there is, indeed, some sort of collaboration between some industrial laboratories and university laboratories. There is, however, generally speaking, too great a lack of collaboration between those centres of scientific life which are formed by the universities, and the research centres in the industrial laboratories. This is partly due to the lack of interest shown by many university professors and assistants, but to a greater extent it is caused by the attitude of the industrial firms and their fear of losing their secrets. Generally speaking, again, there is an enormous overestimation of the value of factory secrets. I am, of course, referring to normal peace-time and not to war industry, and doing this, I believe that, apart from a few isolated cases, many of these so-called secrets are only secrets in the eyes of narrow-minded manufacturers themselves. Either the secrets are actually well-known facts, well known to experts, or they would be found very soon by

a well-organised research laboratory. The stupid fear of losing secrets goes so far in many cases that a further development of the methods of manufacturing is seriously hampered by it. I know an example of a medium-sized factory, somewhere in Europe, where the research chemist—there was only one—was not allowed to enter certain rooms for fear that he might discover the secrets of the process. Another big firm had in its own opinion some well-kept secrets. When on a certain day a very good description of these secrets appeared in a new text-book, this very text-book was banned from the library of the factory, in order to prevent its own research staff from discovering this awful fact.

I worked for many years in a very big research laboratory of a great industrial concern, the board of directors of which were not narrow-minded at all; on the contrary they promoted free interchange of thoughts between their own research men and university people, publication of scientific and technical work of the laboratories, etc. The concern derived great benefits from this broad-minded and sensible policy.

It is my opinion that the leaders of industrial research laboratories must be scientific men in the first place, but they must have also a highly developed technical mind and imagination; they must be able to talk to and to understand the technical people in the factory, as well as the university men, with whom they must have free interchange of thoughts. Some of them may hold a semi-official or official position in a university to promote collaboration. The university people must be stimulated to visit the great industrial laboratories, to lecture there, to discuss problems, etc.

So far about big laboratories, which can only possibly be established and maintained by big industrial firms or concerns. Smaller factories cannot maintain laboratories of a sufficiently large size. Without underestimation of the magnificent work done by some of them, it is my opinion that in modern development there will practically be no place for small research laboratories, unless they have a very intimate and almost daily collaboration with other laboratories. Such a collaboration, however, is seriously hampered by the competitive character of our industrial system. If we base ourselves on the present system, I think the best way in organising research for the majority of the smaller industries will nevertheless be that they get together and collaborate in their joint research interest. The Government should endeavour to bring them together, if they do not do it themselves; and the collaboration of the Government could be extended in this way, that minorities are induced to accept majority decisions, provided that these decisions are in the public interest or in any case not against it. In such a way, joint research laboratories of a sufficiently large size will be possible, and they again can collaborate with the universities. These joint laboratories need not exclude separate laboratories of the individual co-operating industries. I think it would be very wise if all the individual industries had laboratories of their own or at least had one or more scientists serving as liaison units between their industries and the joint research laboratory.

There is in some cases already a detectable tendency to work along such lines. The first task of industry must be to serve the community; if it realises this it will have the unreserved collaboration of science.

Mr. E. D. Swann

The Organisation of Science for War Production[1]

THIS country has always led in the advancement of scientific knowledge, and the use of this knowledge should have given us a corresponding lead in production technique. This, however, is not the case. However fine the work of our research scientists it will never be fully reflected in efficient production until the application of science is planned in a scientific way. The younger working scientists in industry are in the best position to realise what changes need to be made. The first necessity at this time, as it should be in peacetime, is for the full utilisation of existing technical man-power. It was this realisation that led to the setting up of the Central Register. This organisation has made a survey of existing technical man-power and has filled many technical posts. This, however. is only a part of the problem. It is also necessary to make sure that all technical posts are filled and that all possible scientists are engaged upon essential work. An inquiry recently made in industrial and Ministry of Supply factories by the Association of Scientific Workers has shown that this is not at present the case. The problem is not one which can be solved by an individual. A number have already tried to transfer to more important work, only to find that as employees in a scheduled undertaking they are refused release under the provisions of the Essential Work Order. The full utilisation of technical staff necessarily involves transfers, and many men have changed the nature of their scientific work since the war began. Science masters are now working in ordnance factories and so forth. Little consideration is given at present to any special training for these people. They need to learn of recent advances in theory and they need training in large-scale production methods and technique. Neither of these need take long, yet both are of obvious importance.

Besides making full use of present resources, technical man-power has to be trained for the future. This has already been recognised by the deferment of military service for science students, and we welcome the introduction of the State bursary scheme. The present bursary scheme, however, has certain limitations which have led to disappointing results. At present the student is allowed a grant for one year of study after passing his Higher Schools examination. This is insufficient time to permit him to complete a degree course. He is faced with the prospect when he leaves the Services of having no job and no academic qualification. Provision should be made for a supplementary grant to these students to enable them to complete their studies after the war.

The greater the number of scientific staff the more important becomes the need for competent control. Too frequently technical staff are

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responsible to works executives or other persons of inadequate scientific ability. The result of this practice is inefficiency. Unfortunately the state of affairs is extremely difficult for the individual to remedy. Individual initiative must be encouraged ; the industrial scientist is in the front line of war production and is the best judge of the effectiveness of production technique.

The circulation of material is at all times a question of first-rate importance. In peace-time the structure of industry makes it inevitable that there should be some duplication of work in the laboratories of competitive concerns. In war-time such wasted efforts cannot be tolerated. I think a considerable measure of success would be obtained in the solution of this difficulty by adopting generally an arrangement by which development contracts are held by the Ministry concerned, and the handing over of all relevant information made a condition of these contracts. The necessary circulation of information is not limited to research data ; it must be extended to include development and production information as well. The proper dissemination of information demands an organisation possessing three features : first, the establishment of a central statistics and information bureau ; second, the bringing together by means of committees of technical staff engaged on similar work ; and third, the visits by the staff of one plant to others which employ a more efficient technique. War production could be increased immediately without any capital expenditure if information on the most efficient use of existing plant were pooled in this way. The restriction of information to one firm during a life-and-death struggle when it should be made available not only throughout this country but throughout the allied countries is a paramount stupidity. Closer collaboration must be arranged between government designs departments and people with production experience. Technical men on production or engaged on the development of government designs frequently comment on their unsuitability for modern mass production. They also criticise the unnecessarily close tolerances required in manufacture considering the eventual use of the article.

The need for the maximum contribution from science is urgent. The things of which I have spoken demand immediate consideration. They cannot wait until after the war. The necessity for these changes is most appreciated by our young working scientists. The encumbrances of outworn traditions and the hindrances of selfish individualism must be swept away and new methods of collaboration and planning developed. This alone can lead to the effective utilisation of science in the struggle of humanity for a new and better civilisation.

Dr. Enrico Volterra

Some Recent Applications of the Theory of Elastic Dislocations in Civil Engineering

ONE of the chief factors of progress in modern engineering is based on the capacity to utilise to the maximum degree the resistance of the material employed. To this, technology on the one hand contributes, by continuous improvement of the materials available, and by the provision of new ones ; whilst on the other hand, science develops new methods of investigation and calculation.

Two problems which are intimately connected with this progress and which have acquired great importance in modern civil engineering are, first, the study of the conditions of elastic-plastic equilibrium and, secondly, that of pre-stressing structures. The solution of the first enables us to extend our knowledge of the state of stresses and deformations of structures when the elastic limit of the material has been overstepped, and it is in what we call the plastic condition.

This overstepping of the elastic limit occurs more frequently than one would suppose, even in the most elaborately and accurately calculated structures, as is evidenced by the appearance of permanent deflections or deformations which do not disappear even when the external forces which have caused them cease to operate.

The second problem is that of producing within the structure itself, by means of special operations, certain artificial internal stresses favourable to its stability.

I should like very briefly to show, without entering into technical details, how it is possible to deal with both these problems, and how their solution constitutes a new contribution to modern engineering, by means of the application of the theory of elastic dislocations.

An accurate examination of the state of stress and strain which exists in a statically indeterminate metallic structure, a part of which is in a plastic condition, shows that the effect of the plastic deformation is the same as that produced by an elastic dislocation. This hypothesis seems to be confirmed by experiment. It is, then, possible to extend to statically indeterminate structures in plastic-elastic condition some theorems valid for elastic dislocations in multiply-connected bodies. The principal advantage is that it permits us to study structures in plastic-elastic condition by methods entirely similar to those employed in the study of structures in wholly elastic condition. More precisely, it is possible to extend to the plastic state a theorem of reciprocity which has as parallel in the elastic state Maxwell's and Rayleigh's reciprocal theorem, and a theorem of minimum energy, the analogue of which in the elastic state is Menabrea's theorem of minimum energy. The two theorems can be used to study in the most general way plastic-elastic deformations in the most complicated types of structure. The same considerations, developed for metallic material, can be applied, under certain conditions, to reinforced concrete structures.

Particularly important and interesting from a technical point of view are the conclusions which can be deduced by the application of these methods to reinforced concrete arches with very small rise. For such arches, the pressure curve calculated by the ordinary methods of the theory of elasticity is farthest from the central curve of the arch at the crown and at the two abutments. This means that the stresses in the concrete at the crown and at the two abutments would reach very high and often inadmissible values, whereas experience shows a less unsatisfactory state of affairs. The introduction of the plastic factor into the calculation and the applica-

tion of the general theorem of minimum energy suffices to explain the apparent discrepancy between theoretical and experimental findings. The plastic adaptation of the material brings the curve of pressure more nearly into coincidence with the central curve, and reduces to normal values the stresses in the highly strained sections.

We have shown the behaviour of certain hyperstatical structures in cases in which, under external loads, the stress in certain sections reaches the elastic limit of the material. As a consequence, a dislocation occurs, the effect of which is to decrease the stresses in such sections. The stresses will thus increase in other less heavily loaded sections of the structure. This reaction of the material to the external forces which would be expected to destroy it may be compared to a natural defence set up by the structure itself. The idea naturally occurs that one should imitate and supplement the automatic reaction of the structure, by creating artificially certain dislocations which tend to increase the resistance of the section in question to the external conditions under which it would fail, such as permanent and accidental loading, the effect of variations of temperature, of shrinkage of concrete, or the yielding of external or internal links.

The problem in all these cases is to carry out, on the structure itself, where it is being set up, a very delicate surgical operation, since the dislocations to be produced and permanently impressed on the structure are usually very small and it is necessary to adjust them very accurately if one is to avoid an insufficient effect on the one hand, or a remedy worse than the original defect on the other.

These methods have found their most important application in concrete arched bridges. More than 130 years ago, Peyronnet, in France, was casting about for a method of bridging deep valleys and ravines 200, 300 and up to 500 feet across. Present-day actual achievements far surpass his wildest dreams. Consider, for example, the bridge of Plougastel, near Brest—if the R.A.F. have left it still intact—built by Freyssinet about ten years ago, with its three 600-foot span arches.

In a structure of this type, the predominant effect to be counteracted is the shrinkage of the concrete, which proceeds gradually, reaching completion about 18 months after the setting of the material. One operation would be ineffective : the compensatory process must proceed *pari passu* with the shrinkage and, to be really useful, without stoppage of the traffic over the bridge.

The process involves a series of dislocations produced by hydraulic jacks and maintained by rigid metallic wedges introduced into the fabric of the bridge.

In order to avoid interference with the traffic and at the same time to permit repeated operations, a concrete pediment is built on to one of the abutments of the bridge during construction. On this pediment special cradles are left, into which hydraulic jacks can be introduced, and these produce the requisite dislocations at specific intervals. The deformations produced are measured by delicate but simply read instruments.

It is comparatively easy to work out the appropriate dislocations, alike for arches with built-in ends and for the most complicated types of structures : but I shall spare you the technical details and calculations.

This achievement shows a most happy blending of science and technology.

It may seem odd, amid the present widespread destruction, to be considering the magnificent possibilities of building the ornaments of peace ; but we are confident that the present is only a passing phase, from which we shall emerge into days giving us ever wider scope for the collaboration of technician and scientist. For on the increasingly intimate co-operation of science and technology is based the progress of modern civil engineering, from which the continued prosperity and advancement of the human race is inseparable.

Mr. Ritchie Calder

The Second Industrial Revolution

THE illustrations given to us are enough to show us that we are in the throes of a second industrial revolution—new powers, new processes, new materials like plastics, and new techniques generally. I would like to argue—I do not know whether Professor Sargant Florence would agree—that that second industrial revolution potentially is the first revolution in reverse. With electrification, modern transport and communications, we are going to push away from the big centres of which he spoke, and are going to secure a redistribution of industry throughout the country and throughout the world. As we have seen, this second industrial revolution is predominantly one of 'foot-loose industries' which must and will go on developing. If we render it in terms of great projects like T.V.A. we can contemplate a drastic redistribution of industries away from the great centres of population. But if we have an unplanned economy that, of course, will be impossible. This second industrial revolution was well under way before the war. The effect of the war has been the opening of what Lord Stamp, at this Association some years ago, called 'The Icebox.' From that icebox is being released the processes which were being withheld for a variety of reasons, some of them good, many of them bad, for the purposes of war. The release of those processes has given a tremendous impetus to this revolutionary movement of industry. But we are facing in this war an even greater problem than that. Professor Bernal gives the instance of 150 years from the conception of an idea elapsing before it becomes commercially applicable. Some years ago I was working on a basis of a range of industries which gave me ten years for the development into commercial practice. As a result of the war it is something like ten months. That is a terrific speeding-up process. At the same time we have got in uniform, in the Services and so on, millions of people who have been fetched away from industry, or have been put into new kinds of industry. Do not let us forget that we have taken clerks, and so on, out of offices and have turned them into skilled artificers in the various armed Services. It is going to be a great problem at the end of this war to know how we are going to demobilise these people without even

more catastrophic results than after the last war. I suggest that we must look ahead now to the question of training and so on, for what I should like to call 'flexibility in industry,' a training such that people can be moved from one phase of industry to another. Then we shall simplify the problem; but it does mean looking ahead. I do not want to develop this theme at this late hour, but I would stress what has been stressed many times during this Conference—that what we want in the future we must start to consider and plan for now. We know that legislation made in war may remain, and that organisations, unless we feel as we were feeling at the end of the last war, will remain, and controls will remain. I suggest that out of the present situation we ought to develop the kind of mechanism that we want to see existing at the end of this war—the building up of relationship between the scientific organisations and the organisations in Government. It ought to be a product of this Conference, as the President said yesterday, to form research committees. We have had more than enough from the discussions this afternoon to yield us specific problems. I urge that these research committees should be concerned with specific problems and not given too broad a basis. We ought to tackle these specific problems and use them as illustrations for our argument, that there ought to be proper co-ordination now between scientists, not only here, but in the international field as well. We should take advantage of our close relationship with the U.S.A. and with the U.S.S.R., and with the leading scientists now in London, not merely to build up national organisations to deal with this great revolutionary potentiality of industry which we have been discussing this afternoon, but to co-ordinate in such a way that we would have in war-time some comprehensible model of what we expect after the war. From this Conference, the British Association should initiate an international organisation which will enable us to gain from this Conference and from the discussions such as we have had this afternoon, a very clear conception of what we are going to do with the great potentialities of industry and of science after the war.

The Chairman

BEFORE I close this meeting I would like to make two short remarks, the first scientific, the second political. We have listened to various papers and to the discussion of different and extremely interesting problems relating to co-ordination as between technics and research and their application in practical life. There is one thing which has struck me with regard to what we have heard this afternoon, and I think it must have struck everyone present, namely, the growing spirit of social responsibility shown by men of science and by modern technicians which is evident in all the contributions to which we have been listening. We are definitely in the age in which science is being practised, not for the sake of itself alone, but for the sake of social life, for the sake of life based upon the high principles of humanitarian belief. In modern science there is no longer any art-for-artism. In future there will be no difference in appreciation between pure and applied science. There is not any other science than pure science. If there is impure science I think it is this science which has established or invented the pure race.

If I may revert to what I said at the beginning —and this is my second remark—I should say that we can see a further indication of the general phenomenon of the modern technician becoming increasingly conscious of the tremendous possibilities for good as well as for evil of the weapon he holds in his hands. Scientists and technicians have begun to think not only in terms of their science and its applications, but also in terms of social morality. They want their inventiveness to receive moral and social consecration. It is a consciousness which also determines our stand in the present stupendous world conflict. If I were to name one outstanding reason which condemns totalitarian dictatorship, beyond all question it is the fact that it converts the divine gift of human inventiveness which was intended to be used in conquering and subduing the forces of nature in the interests of human happiness, into an instrument for the enslavement of man and of the human spirit. It is a spiritual as well as a material crime, and in all codes of ethics the first has always been held to be the less pardonable of the two. So I conclude that this is how it comes about that, while it is right and proper that we should pay appropriate attention to problems of the world order that we desire to issue out of the present turmoil, we must not lose sight of, indeed we must devote our utmost effort to, the main task to-day in pressing to a successful completion, which forms the one inevitable condition on which depends the very possibility of any realisation of our scientific and social planning, this dreadful war by which we shall secure the complete, total and unmistakable defeat of Nazism and all that its name stands for.

SCIENCE AND POST-WAR RELIEF

SUNDAY, SEPTEMBER 28: MORNING SESSION

CHAIRMAN: H.E. THE CHINESE AMBASSADOR, DR. WELLINGTON KOO

The Chairman

THIS morning's session of our Conference is to be devoted to the subject Science and Post-war Relief. Out of the present terrible conflict there will arise upon its termination widespread calls for succour and help. The needs of care for the sick, food for the hungry, nourishment for the young, housing for the homeless, prevention of epidemics, and many other forms of assistance will be pressing.

It is fitting and proper that this great and representative body of scientists from many lands, in striving to aid with their knowledge in the preparation of a new world order, should give their attention to the possibility of rendering scientific help in the indispensable work of providing for want and alleviating distress in the afflicted countries.

Post-war relief, like every other important task, requires planning, and science can do much to facilitate it. The trying experience of relief workers at the end of the last world conflagration shows clearly that rationalisation and co-ordination through the use of scientific methods are necessary to the accomplishment of efficient results free from delay and waste. Thanks to the painstaking efforts of those who have organised the present Conference, we have with us a number of distinguished scientists from different countries who have consented to present special papers on various scientific aspects of the problem of relief after the war. It will be our great pleasure to listen to them in due course.

There is, however, one point of a general character upon which you will allow me to dwell briefly. The subject for this morning's session constitutes only a part of the programme for the whole Conference. Valuable discussions in regard to certain aspects of the relation of Science and World Order have taken place in previous sittings, and more contributions will yet be made on still other phases of the problem before the close of this present unique gathering. But the underlying purpose of all our deliberations is to promote, by application of the knowledge which science has contributed to humanity, the creation of better conditions of life and work after the present ordeal.

For the realisation of this lofty ideal, there is a preliminary condition to be fulfilled. I am sure you will all agree that the possibility of building a better world in the future depends upon the outcome of the struggle in which we are now engaged. The only foundation upon which a magnificent and permanent edifice of peace and security, of freedom and democracy, of justice and prosperity can be firmly erected, is a complete and final victory over the forces of violence and disorder. As the President of the British Association has so well said in his inspiring and admirable opening address, ' Between the free commonwealth of science and the Powers which are making a mockery of truth and righteousness, there can be no compromise.' Indeed, if the present world should continue to be dominated by aggressive force and cultivated barbarism, not only will science cease to flourish in the absence of freedom of thought and expression, but civilisation itself will wither and die for want of fertilisation.

I hope the victory which we all ardently desire will be achieved soon. And the sooner the better, for it will thus bring us nearer to the attainment of our common object—the establishment of a better world order. This is no less important in regard to the subject of this session. The problem of post-war relief exists only because of the great havoc which is being daily wrought by the forces of destruction launched by a group of militarist nations bent upon conquest and domination. When this mad enterprise of the warlords of the world is defeated, the fiendish processes of devastation and rapine accompanying it will cease to function and the scope and extent of the task of relief can be appraised and circumscribed.

I know that all of you have been contributing your share to the general effort for the cause of freedom and civilisation. In China, Chinese scientists have also been playing an important rôle in the dual campaign of resistance to invasion and reconstruction in the rear. Their knowledge and technique are fully enlisted in the service of the national cause which is also the cause of freedom and democracy. With the resources of science at your command, you will, I am confident, continue to exert yourselves not only in aiding the prosecution of war but also in devising means to hasten the achievement of victory. Only the full success of our common struggle will provide the necessary groundwork for remodelling the pattern of our civilisation. When this basis is created, we can then build according to our plan, and the new edifice of world order, because it is aided in design and construction by the genius of science, will be all the more beautiful in form, richer in contents, and more durable in structure.

Mr. Philip Noel-Baker, M.P.

When aggression is defeated in the West, in the Mediterranean, and in the Far East, every country where Hitler now rules will be starving. We have promised to send them immediate relief. President Roosevelt and Mr. Churchill have told us that the stocks of food are already being prepared ; the Allied Council have appointed a committee to draw up plans for allocation, assembly, transport and distribution. We know that all Europe will be bankrupt ; that this work will be done on the lease-lend basis ; that we must advance, and be prepared to lose, great sums of money, in order to meet an overriding human need.

What results shall we obtain from this vast action of post-war relief—by far the greatest deed of collective charity in the history of man ? Shall we save a few scores of thousands, a few hundreds of

thousands of threatened lives? Shall we end the hunger a few months sooner than the conquered peoples could end it for themselves, leaving no further trace on the course of world affairs? Or shall we make of this relief the starting-point of a great forward movement in the physical well-being and the material prosperity of all mankind? Science has made it possible for us to ask the question; science has shown us quite plainly what the answer ought to be. When I face the question three memories come into my mind.

The first is this: Some years ago I visited a school in a Midland town. A class of little girls of nine were learning arithmetic. I looked at their books; on one side of the room the children had got all their sums quite right; on the other side they had got them all wrong; indeed, some of them did not even know whether they were trying to subtract, divide, or add. I asked the teacher what this extraordinary difference meant. 'Oh,' she said, 'I separate off all the little dunces,' and then she added: 'But they aren't dunces really. They just don't get enough to eat.' I was struck with horror at the vast social waste which this ingenuous, unpolitical young woman had revealed.

My second memory is of the Peace Conference in Paris and of the League of Nations, in both of which our Chairman of to-day played so eminent a part. At the Peace Conference I worked for Lord Cecil. Among his other duties he was chairman of a body called the Supreme Economic Council. Its secretary was Sir Arthur Salter. Its purpose was post-war relief. It did great things to restart the economic life of Europe, and supplied great sums of money, great quantities of raw material and food. But it was a temporary, allied body; in a year or two it was disbanded, and, with all its work, it disappeared utterly and for ever into the limbo of unregretted, forgotten things, leaving no permanent political result behind it, leaving no permanent effect on world economic policy of any kind.

A year later I had to help Dr. Fridtjof Nansen in his capacity of League of Nations High Commissioner for the Repatriation of Prisoners of War. Dr. Nansen obtained from the Supreme Economic Council a tiny sum of money—less than half a million sterling. With that, and the help of individual Governments, he repatriated half a million men. But he was acting for a permanent international political organisation, the League of Nations. When the prisoner work was ended, it was not forgotten; it produced a considerable and permanent political result. And Nansen's High Commission was not abolished—it was used for other and greater tasks: for the care of one million Russian refugees; for the settlement of one and a half million Greek refugees, and so on. It produced great and continually expanding practical results; it created new precedents in the then growing science of international government and administration.

My third memory is about the settlement of those Greek refugees. In September 1922 Greece was all but down and out. She had had ten years of war; her armies had been beaten in Asia Minor; she was in the throes of an internal revolution; her towns and provinces were flooded with homeless and penniless refugees. Nansen decided that there was no solution except to settle the refugees in Old Greece, and to do so with a League of Nations loan. But he warned the Greek Government that the League conditions would be severe. I remember still how the Greek Foreign Minister, M. Politis, instantly replied: 'We accept their conditions in advance.' And he put through in a few minutes a scheme of League control to which in normal times no Government could have possibly agreed.

I believe those three memories teach the essential lessons about post-war relief.

Our despatch of food may be an isolated action, administered by a temporary agency, without lasting authority or power; it may relieve Europe's immediate hunger, but may do so without changing in any way the permanent food policies which Governments pursue. Or we may use the great opportunity it gives us to force through new policies, to build up the authority of a permanent international administration, and thus to make it the start of a great and permanent advance.

But if this is to be done, scientists must go on making Governments understand the social waste which an inadequate diet really means. When I remember those little dunces in a Midland school, I remember, too, how boys in London, who for a year were given a pint of milk a day, gained 43 per cent. more in height and 81 per cent. more in weight than their fellows; how they had less illness, did better in games and class. I remember the judgment in the League of Nations Nutrition Committee's Report in 1937 that: 'A problem of malnutrition unquestionably exists even in the countries of the highest general planes of living, while in others less fortunately placed the evil is more widespread.' Sir John Orr has told us that in this country 45 per cent. of our population have an inadequate diet; in the United States it is over 30 per cent. I remember, too, that a proper diet can wipe out rickets, beri-beri, scurvy, tooth-decay and other diseases.

Recalling the famous figures about Epsom and Merthyr Tydvil, I remember that a proper diet can vastly reduce tuberculosis, that it can halve infant mortality, increase the expectation of life, increase the strength of muscles and brains and nerves, that is to say, the wealth-producing power of children and adults.

I remember that Dr. McGonigle in Stockton-on-Tees—and, indeed, the British blockade of Germany in the last war—proved that food is more important to health than any other single factor—housing, clothes, medical attention, or whatever it may be. I remember that, thanks in great part to the League of Nations Health Committee, who began the work as long ago as 1925, we have an international standard of adequate diet—what Sir John Orr calls 'a minimum standard for maximum health.' We know how much of the energy-producing foods, of the protective foods and so on, everyone should eat. That is to say, we know what our food policy ought to be. We know, with mathematical certainty, that if we could give everyone the 'minimum standard for maximum health,' the whole community would be healthier, happier, richer in every way. And we know that, if we plan it right, the world can produce the necessary food; that, as Mr. McDougall, a very high authority, calculates, we could do it for

North America, western Europe, and Australia within two years after the end of the war, and for the whole of Europe, perhaps, in eight or ten.

Knowing these things, ought we not now to resolve that a sound food policy, a minimum standard for maximum health, ought to be our starting-point in our plans for post-war relief? Even more, ought it not to be the basis of our long-term economic schemes?

In the Atlantic Charter, now endorsed by all our Allies, sixteen Governments have pledged themselves to establish a peace which ' will afford assurance '—these are the portentous words—' that all the men in all the lands shall live out their lives in freedom from want.' Freedom from want—how are the Governments going to do it? By abolishing slumps and unemployment? Yes, the Foreign Secretary has said that we must do that, if we are to hope for lasting peace. But it will be a long and a difficult job. What easier, what sounder start could they make than by an international agreement that they would strive by every means to ensure the international standard diet to every citizen in their respective lands? If they could do that, if they could fix a high minimum demand for every kind of foodstuff, they would go very far towards stopping slumps. For two-thirds of all the world's population still live and labour on the land, and the stability of the markets for their products is by far the most important single factor in controlling the fluctuations of world trade. Such a policy would mean difficulties on the production side; big adaptation in the agriculture of different lands; the United States would need to use at home all its agricultural products except cotton, tobacco, and a little wheat; Great Britain would have to produce 50–70 per cent. more fruit and vegetables; nearly 100 per cent. more butter and milk; and, in consequence, we should have to give up growing wheat and sugar-beet; France would have to reduce its wheat production from 100 per cent. to 70 per cent. of its requirements; Switzerland would have to give up growing wheat, as it does now, at a cost of three times the world market price; in some countries, for example Hungary, the whole system of agricultural production, and, indeed, of land tenure, would have to change. But these things could easily be done if, starting from the basis of the international standard diet, world food production were adequately and intelligently planned.

Far more difficult than planned production is the question how consumption can be assured. The fundamental trouble is that the incomes of a great proportion of the workers are still too low. Shall the Governments, then, simply buy the food and give it to their citizens, as they give them water and drains and roads? If not, are we not forced back to the wages question, to the purchasing power in the hands of the individual man?

For my part, I hope and believe that the International Labour Office will be compelled to work for international minimum wage standards. But that, too, will be a long and a difficult business. There are other things which could be done more quickly to help the execution of a world food policy plan.

The Governments could abolish the excessive tariff duties which they had on all food imports before the war—this, indeed, is an indispensable condition to any real food-policy advance. They could agree so to work their subsidies to agriculture as to support and strengthen the operation of the international plan. They could reorganise transportation, marketing, and distribution, cut out the excessive profits of the middle-man, and so reduce the prices which the poor must pay. They could establish National Nutrition Councils—there were fourteen of them in 1937—to educate and plan. They could improve their methods of agricultural production. Above all, they could enormously increase the communal food consumption, for which the Government itself would pay.

In saying this, I have in mind the pithead canteens which some of our miners are finding such a success to-day; I have in mind the distribution of free milk and other nourishment for nursing and expectant mothers through Government clinics or in their homes; above all, I have in mind the ' Oslo breakfast,' free meals in the schools, which have produced such magnificent results in the Scandinavian countries. Why should not every child have a pint of milk and a properly balanced meal at school every day, cutting out the means test, and letting the nation pay? Is there any finer investment we could make? Could there be any better start towards freeing all the men in all the lands from want?

None of these things will be easy; powerful vested interests may have to be overcome. But our relief work will give us a magnificent opportunity to begin. If the scientists can make the Governments and their peoples understand the possibilities that lie open to them, and where their true interests lie; if the Governments will treat relief as the first stage in a long-term policy of world-wide scope; if they will hand it over quickly to the permanent international institutions they set up; if they will remember that when the war ends Hitler will have destroyed all the old European tariffs and will have changed all European production; if they will use that unique opportunity to replan and to establish a new system which, if we lose that chance, Governments may not for very long accept—if they do these things, and will mobilise to do them the dynamic power of the opinion behind the Atlantic Charter—then, I believe, in the words of the League of Nations' 1937 Report, ' new perspectives of human welfare will be opened up,' then they will really begin to free all men from want.

But Sir John Orr's International Committee must be appointed; and it should be appointed now.

Prof. Julius Löwy

A Proposal for organising the Natural (Physical) Curative Resources of Europe for Post-war Relief on an International Basis

THE health situation in post-war Europe will be influenced by three main factors: under-nourishment, overwork and the consequences of persecution and oppression. These influences have an equally harmful effect on the bodies and minds of both the sick and the healthy. The work of the health services will thus have to be extended so as to cure the former and help the latter to regain perfect health.

We need not refer to past statistics to predict

that tuberculosis, heart disease and vascular diseases will increase in number, and that resistance to all kinds of infectious diseases will be reduced. In addition, the health of the coming generation will certainly be undermined. We know that children born and brought up at a time when the mother is suffering from industrial exhaustion are sickly; there is also the effect of the various poisons in industry, which harm the male and female reproductive cells, and thus undermine the constitution and resistance of the coming generation. We need not go into any more detail. It is only too well known that wars have always had a deleterious effect on the health of the nations concerned, and this war, in view of its totalitarian character, will be especially harmful to the health of all the peoples on the continent of Europe.

The problem will be to overcome this evil in the shortest time and in the most effective way.

The health services of the various States of Europe, which vary in their degree of quality and were adapted to normal needs, will not be equal to the great demands which will be made upon them. Funds will be insufficient and the import of medicaments will be hindered by transport difficulties. Our proposal is, therefore, that the natural curative resources of Europe, such as sunlight, sea and mountain air, climatic factors and medicinal springs, should be used more systematically than hitherto.

No State in Europe possesses all the natural curative resources in question. But if a number of States co-operated in offering these resources in an organised way to the ailing population of Europe, their health and fitness would be much more speedily and surely restored.

After the last war much of this kind of thing was left to private welfare organisations. It will be remembered how the Norwegians extended their hospitality to Austrian children. Acts of private generosity such as that will not be likely after the present war. It would therefore be advisable for machinery to be formed immediately after the war to take the place of private charity and organise the use of the available climatic factors and curative springs on a large scale by those suffering from disease and exhaustion.

The basis of this kind of organisation would be an 'international health union,' if we may put it so, which would recognise no frontiers. A group of countries needs to be found possessing all the natural (physical) curative resources in sufficient measure and ready to place them at the disposal of the sick population of Europe.

My proposal is that a body should be appointed to perform the two following tasks: firstly, to draw up a scheme for the international use of the natural (physical) curative resources of Europe in a practical form so that it can furnish the basis for the treatment of sick persons and those in need of recuperation immediately after the war. The second task of the committee would be to consider the means—especially financial schemes—for putting this proposal into practice as soon as the war is over. It is not impossible that an emergency organisation of this sort might develop into a lasting international institution.

A provisional plan would have to be worked out on the basis of detailed study, and the needs of the different countries as well as their curative resources taken into consideration.

In the first place, as all available physical curative resources, such as sunny mountains, seacoast resorts and inland spas, should be made use of, the easier part of the task would be to sketch out the area containing the elements needed for sick persons and those in need of recuperation. It is quite clear that the value of the different resources would vary greatly and the different countries would be able to contribute in different measure. An exact assessment of the effects of the different climatic factors would render possible a fairly regular distribution of patients, thus preventing any of the countries from becoming overburdened materially. For example, different parts of the long coast-line of Europe produce quite different effects, varying from the bracing climate of the North Sea to the mild climate of the Mediterranean and the Adriatic. The climate inland at an altitude of under and over 1,000 metres also shows various indications. An approximate estimate of the capacities of these districts is not difficult. The capacity of the more renowned inland spas is generally known; and it is an additional advantage if it is known for which diseases they are indicated. In Czechoslovakia alone we have baths for the cure of skin diseases, tuberculosis of the bones and joints, the later stages of syphilis, diseases of the nervous system, of the circulation, of the respiratory organs, and of the blood, diseases of the urinary tract and of the digestive tract, endocrine and metabolic disorders, diseases of the organs of movement and of the organs of generation.

The second and more difficult task would be the valuation of the human material according to the intensity and nature of the disease. Here three distinct groups may be distinguished:

(1) Delicate and convalescent children in need of mountain and sea air.

(2) Workers in the various war industries suffering from systemic poisoning, in the elimination of which climatic factors stimulating metabolism may play a great part.

(3) A great number of cases of common diseases, such as tuberculosis, heart disease and vascular disorders, nervous disorders, etc., which will appear in even more intensified form after this war.

If this great humanitarian task is to be undertaken the question will have to be studied from numerous angles. On the purely medical side, the climato-therapeutic and balneo-therapeutic aspects must be especially looked to. In dealing with large numbers of patients, economic and financial questions will also play a decisive part.

The international body set up to study the question should thus contain both doctors and experts on social insurance, whose experience may prove invaluable in solving the economic questions arising from the scheme. The formation of a central international health board, which would help the various States to pool their curative resources as well as their sick populations, would be the result of this study. The various States would not have to fear great expense, since a greater part of the scheme could be financed by

existing or newly established social and health insurance institutions, and the cost as from one country to another would be approximately balanced between the different countries by the many curative factors utilised.

Dr. R. Allen
Red Cross Relief in Europe

THE American Red Cross has been concerned with immediate relief problems, and we are only just getting round now to study the problems of the post-war period. During the last two years the American Red Cross has given extensive relief in China, France, Poland, Finland, Belgium, Yugoslavia, Greece, Spain, Hungary, and Rumania, and now we have a Commission in Russia. I have recently returned from France, where I have spent eighteen months. I have also got into Belgium, Switzerland, a part of Germany, and Spain. Perhaps if I speak very briefly of the situation as we found it in France it would illustrate the point, because the conditions in all those countries are more or less the same.

In France we found that the hospitals were completely denuded of all supplies, that the German conquerors had taken not only the buildings but all the equipment and supplies, and the French people were left to set up hospitals in churches and schools, and were actually using instruments which had been purchased in hardware stores rather than through medical supply houses. We distributed medical and hospital supplies throughout the hospitals of northern France. We did this quite alongside the German army. We enjoyed splendid co-operation from them; they did not take any of the supplies which were intended for the French.

This spring—that is, beginning about the first of January of this year—we distributed milk to all the children under fourteen in unoccupied France. We have not distributed any food products in countries occupied by Germany. We have had the great pleasure of seeing the children of unoccupied France gain in weight. We fed those children one pint of milk each day. The pint of milk was a specially reinforced powdered milk, with an added fat content and an added vitamin A and D content. We were told by the Rockefeller Foundation, who were working with us, that the child was getting all the nourishment he needed to keep him well when he got that pint of milk, although, of course, he did not have all he needed to keep him happy.

We are trying now to work our reservoir of medicine and drugs from Geneva, so that they can be used in the case of the development of any serious epidemics in Europe, and there is, of course, a real threat of that. We are endeavouring to send medicine and hospital supplies into Norway, Holland, Belgium, Yugoslavia, Greece, and occupied France. Here I have had the pleasure of sitting in conference with representatives of the Governments of Norway, Belgium, Holland, Poland, Czechoslovakia, Greece, and Yugoslavia, in doing some post-war planning. Having seen at close range the problems that now exist in Europe I am convinced that it will take the full co-operation of all the scientists and business men and all the Governments of the world to correct the conditions that exist there to-day.

Mr. W. S. Kelly

I CAN remember my father's battle with the problem of pioneer land settlement in Australia. The land, when cleared and ploughed, looked fertile and full of promise. For several years the crops were good. Then they fell away and one failure followed another. Rubbish and thistles would grow, but it all seemed hopeless for wheat. 'The land was worn out,' we were told. Then an experimental farm nearby demonstrated that a revolution followed the use of phosphate. Prof. Lowrie, the prophet of phosphates in our country, explained to us that the land, though apparently fertile, was lacking in phosphates, and contended that its use would change the whole position. Soon all the men were making tests on their own farms with splendid results. Then Farrar, the plant breeder, gave us shorter strawed and heavier yielding wheats, and other men taught us how to combat disease. So, thanks to science, the wheat era came to Australia and homes were pushed out into the scrub and more and more land was subdued. But some land was settled with too low a rainfall, and other was overcropped and the humus burned out. Again the crops began to fail, this time through lack of nitrogen. Once more we were told that the land was 'worn out.' Then the prices slumped. Europe was growing wheat for war rather than butter for human welfare. American wheat acreage had been increased to a startling degree. Far more was being grown than was wanted. We were in trouble again. Could science pull us out a second time?

In the meantime, refrigeration had become generally adopted and that gave us a second string to our bow. We could now send something more than wheat to the Old World. But our sheep were largely kept in the back country. The areas of better rainfall were chiefly used for wheat and the pastures were mostly poor. Quaintly too we had not enough logic to apply the superphosphates that had so helped the wheat to the grass lands. But some experiments at top dressing had shown good results, and we were bidden to try. Again the results were startling. I remember the sudden realisation of the tremendous significance of that improvement. So we started a campaign for pasture improvement all through the rainfall areas of the Commonwealth. With better pastures and a good climate the inside areas could now turn to wool, lamb, beef and butter, as alternatives to wheat growing. So we took up animal husbandry in real earnest.

Of course there were still troubles enough. With heavier stocking animal diseases have become more serious. But here, too, the scientist is helping us. In some districts serious mineral deficiency diseases have shown up, but many of these have been cured by adding cobalt or copper, sometimes both, to the licks. This in turn led us more recently to apply copper direct to the land, and now in some areas powdered bluestone is being applied in tiny quantities but with splendid results, the copper helping both the vegetation and the health of the stock. Truly the victories of peace often remain unsung. Take our sheep population as an illustration. Despite a number of widespread and severe droughts over the period, our sheep numbers

have risen from 70 million at the beginning of the century to 123 million last year. This makes an increase of 53 million over 40 years, a number equal to the present total sheep population in U.S.A. This increase has resulted from better pastures and more adequate fodder conservation and hand feeding. At the same time the quality and weights of wool per sheep have markedly improved. Nor have we nearly finished development along these lines. The carrying capacity in many districts can still be doubled. Moreover the swing to animal husbandry has helped many farms to regain the fertility that had been so wantonly lost.

Yes, science has aided farming in Australia without a doubt, but to what end? Many of us were so engrossed during the last two decades in improving farming practice and livestock that we did not give enough thought to the market problem. Then we were told, not merely that wheat was in over-supply, but also that the world no longer wanted the other foods we had taken such a pride in growing. When we looked up from our engrossing job of growing these good things, we were faced with quota restrictions.

Research men in Britain, the Continent and America have now taught us how widespread is the need. We know now that the children of the poor have been subjected to disease and dwarfed lives for the want of more and better food. Yet good food could not be sold! That surely is too stupid to be allowed to persist! Now, when the fighting ends, hunger and perhaps famine will still remain to be conquered. The Allies will have accumulated great quantities of goods. These will probably be purchased by a Reconstruction Commission, whose first obligation will be to get the hungry people fed. We have learned from past experience that there is no security for a wealthy nation while need surges all around. Economic isolation is hopeless. It will be essential, therefore, that in the urgency of the immediate post-war period we take the risk of being generous, if only because it be the smaller risk. During this period of urgency the doctor must be called in. It will be for the medical people to tell us just what are the most essential needs and how best they may be filled. In the meantime, it would seem to me that we should go much further than is yet being done in the storage of concentrated foods, such as dried meat and milk, in countries like Australia and New Zealand where we are still embarrassed by surpluses. There will be a tremendous demand, particularly for the high protein foods, which are going abegging in our country to-day. But we must go much further than merely giving first aid. Surely with the capacity to produce which is now available, we shall not be satisfied merely to regain what we have lost during the war. Men are looking expectantly for something better than that. They feel that with the victories of science life must be made more adequate for the average man. That hope will not easily be damped down.

But if the reconstruction is to be soundly based, it must involve a regular interchange of goods. Not on the scale of the pre-1914 days perhaps, for the countries have developed a diversity of production, and to that extent are less dependent upon international trade. But the interchange must still be great if we are to raise standards, for trade and prosperity go hand in hand. If the New World is going to provide the extra foodstuffs necessary to raise the nutritional standards of the Old World, what are we to take in return? It is plain that trade must flow both ways. What are our needs? I can speak for Australia, where verily we have needs enough, particularly in the country. The crude little homes on many of our farms and in country towns cry aloud for comforts and amenities. They often lack reasonable lighting, electric power, proper water supply and lavatory conveniences. They are poorly furnished. The food cannot be kept from the burning heat of the summer. The farmer and his wife often have to work like slaves because of the lack of help which they cannot afford to engage. Yes, surely we have need enough if only we can market our foodstuffs. And I gather we Australian farmers are not unique in this regard. Not that we must import all our amenities. Many of them can now be produced at home. Manufacturing industries are now operating very efficiently and these help to stabilise life in Australia and in other lands. But with all the need of our country life and the development that is still to come, we can surely take much that will make life better for our people in exchange for our wool, meat, butter and wheat.

Despite the abuse of the earth's resources, in many parts followed by falling fertility, erosion and other difficulties, science has enabled man to produce food and fibre for clothing in relative abundance. We can and should push this production much further yet. But even before the war we were being warned not to produce more of this or that. We had to work with one eye on the quotas, we dare not give ourselves with abandonment to the task. And all the while, it has now been shown that in other parts of the world malnutrition was thwarting and stunting human lives. Now we know that if the nutritional needs of the peoples are to be fully met, we must go all out in producing the good things of life. Surely we will no longer permit the madness of a general restriction policy, because of a so-called surplus, while the poor and needy suffer from hunger. And this solution would be twice, nay thrice blessed. For if the nutritional needs of the people are fully met, not only will public health be improved, but our agricultural problems will be largely solved and the flow of international trade stimulated.

Mme. H. Priestman-Bréal
The Psychological Approach to Relief and Reconstruction

Most of the countries of Europe, when they are set free from Hitler, will be in grave need of help. Relief and reconstruction in other countries offer a great opportunity for international friendship and understanding, but one that may easily be misused even with the best of intentions. Skill and wisdom are needed in such matters, or some of the results may be quite the opposite of what was intended. The people we meant to help may be left better off materially, but sore, humiliated and indignant—though often unjustly. Much can be

learnt from attempts at relief work after the last war. My personal experience of this was limited to fifteen months which I spent in East Poland in 1922–1923 with the Friends' Relief Mission. The Mission was called in to fight typhus, of which there was a bad epidemic in 1921, but they soon found that this would be of little use by itself. In the district where I worked (it had changed hands eight times since 1914) refugees returning from Russia or even from as far as Siberia, often on foot and almost always after travelling for several months, even if they did ride in cattle trucks part of the way, found quite unexpectedly (for they had had no news since they left) not only that their homes and possessions were destroyed, but that their fields had become thickets of small birch, two or three feet high. They had only their bare hands to pull them up. Many felt that all they could do was to lie down and die. Merely handing out food or even tools seemed unsatisfactory. These people must be set on their feet again and given new courage and hope. There is no time to mention our many unsuccessful attempts, though several were instructive. But apart from the work in towns, with which I had little to do personally, the following schemes in the country seemed to give the best results.

A thousand horses bought from the army were organised into 'ploughing columns.' One morg (1½ acres) was ploughed for each family with the help of the peasants themselves. Enough seed was given them (including flax seed) to sow their land, and they had to undertake to return the same amount after their harvest. Many could not write and had to put a cross instead of signing their names, but on the whole they were most scrupulous about paying this debt.

Meanwhile, the people lived largely in old trenches, dug-outs and huts. The Government gave each family a voucher entitling them to so many trees to rebuild their houses ; but these trees were still standing, and sometimes as far as 10 or 15 miles away ; so in winter our horses were used for timber-hauling—the peasants again providing the labour, hauling their own wood and, if possible, also wood for some helpless neighbour, widow, cripple or orphan.

The women were given wool, sent in whole fleeces from Australia, to spin and weave, and received Hoover food rations as well as a small money payment in exchange for their work. They also did most beautiful traditional embroidery on hand-spun or hand-woven linen. This was later sold in England and America.

All these schemes, and others like them, encouraged the people to help themselves and to co-operate with the relief workers, and so were better than mere distribution of supplies, which is apt to encourage begging. But even so, apart from numerous material difficulties, and difficulties in organisation, there was room for much misunderstanding. Everyone cannot be helped ; and it easily seems that the favoured ones are arbitrarily selected. Whatever guiding principles and whatever rules are adopted, they should be explained as clearly as possible to the people concerned. These explanations, and the detailed instructions, which, as we shall see, are often needed, might be made much easier by the distribution of radio sets in the villages with loud-speakers, say, in the cafés, the mairies and the schools.

It is important to know the country and the people—and important also to speak the language fluently and intelligibly. Many of our workers used interpreters, and that is far from satisfactory ; contact with the people is much less close ; and really faithful interpreters are exceedingly rare. Also, filling in case cards requires great patience in questioning, and a good deal of vigilance, to avoid cheating. Here, too, a thorough knowledge of the language is desirable. But most important of all is the attitude of individual relief workers. A superior attitude is fatal. The nervous condition of the distressed is usually very bad. Often all they have left is their pride—particularly their national pride. It easily takes silly and irritating forms, but needs very gentle treatment.

Should one employ local people in relief work ? Yes and no : people of the country concerned, yes, though usually to work in close association with others ; but rarely in their own town or village, where they are too much exposed to accusations of unfairness or favouritism, whether well founded or not.

Clear explanations and instructions should also be given about what is being done or distributed. For instance, the Hoover ration contained, among other things, half a pound of cocoa. Often the peasant women would bring it back and ask to exchange it for the same amount of white flour. After a while I inquired why. 'Well, it doesn't bake very good bread.'

In the parts of Poland where I worked—among White Russians and Lithuanian peasants more than among Poles proper—the people were comparatively very primitive. Relief work of some sort will be necessary in far more highly developed countries, such as France and Germany. There, though certain difficulties will be less, the danger of giving offence will perhaps be greater still. It will be all the more important to enlist the co-operation of the people helped—and at the same time more difficult. Those who know more about Germany than I do will no doubt be able to point out the special difficulties to be faced there ; but I am still painfully conscious of the misunderstandings that followed the last war in my own country, France. For various reasons, for which both sides were at least partly to blame, the French felt, often most unjustly, that they had been let down by the British ; on the other hand, in spite of considerable political ill-feeling between the two countries, I could see many signs of a lessening of the old hostility of the English common people against the French, due no doubt to the fact that so many English soldiers had actually lived among French people : the whole attitude was quite different from before 1914. Perhaps this helps to explain the very remarkable fairness and forbearance and k ndness now shown to the French by the great majority of English people. Practically all French people now in England appreciate this, but in France the misrepresentations of German propaganda have not been altogether without effect. Many people in France will certainly be entirely friendly ; but I foresee that others will feel almost intolerably ashamed ; and they are quite likely to show it by developing an absurd touchiness, and an inability to endure the

slightest criticism of the French attitude, if offered by a foreigner. I am not sure of the remedy—certainly not flattery ; probably sticking to practical matters with as little insistence as possible on the moral side, coupled with friendly consideration for individuals, at which the English can be particularly good when they forget that they have to set an example. It will be specially difficult for the Free French, when they go home, not to be accused of putting on superior airs. Whatever they do or say their return is bound to be difficult. It may be worth discussing with them now in what ways it could be made easier. It will probably be important for them to be careful not to seem too extremely pro-British.

Relief workers should try as far as possible not to appear too rich. In Poland, all British and Americans were assumed to have unlimited wealth ; and too often they behaved as if they had, offering to buy up whatever took their fancy, whether the owner wished to sell it or not. Those who deal directly with the people must not be too detached or aloof, nor show too much preoccupation with methods and principles, but beforehand an impartial and scientific approach to the whole question is much to be desired, and a detailed study of the problems to be faced, both material, and, not least, psychological.

Sir E. John Russell, F.R.S.

Re-establishment of the ' Scorched Earth '

WESTERN Russia and the Ukraine are now suffering a devastation unparalleled in human history. As the enemy advances the peasants burn their villages and destroy crops, livestock, and everything else that they cannot carry away. It is their traditional way of meeting the invader. You will remember Tolstoy's description in *War and Peace* showing how thoroughly this was done in the Napoleonic War, and his penetrating comment : ' the peasants knew this always had been so and always would be so '—and once again it is happening. In our time the Chinese expression ' scorched earth ' is used to describe it. The inevitable consequences are famine and pestilence, and large-scale relief will be necessary immediately war is over. Agricultural reconstruction will be equally important, and certain steps should be taken now. The destruction is very thorough. In northern Russia cottages and other buildings are almost all of wood, including even the roofs : nothing remains after they are burnt. On the steppe the cottages are often of loam—a kind of *pisé de terre*—with straw thatch, and although the walls do not burn they soon crumble after fire. In the Ukraine more wood is used, but straw thatch is common, and here too destruction is complete. It is the peasant's passionate love for the land which accounts both for his unyielding resistance to the invader and his fierce destruction of everything lest it fall into enemy hands.

Fortunately the soil itself is not likely to suffer permanently. Temporary damage there will be, but not beyond the resources of Russian science and engineering to repair. There seems no reason to expect actual physical loss of soil. The rainfall is too low for erosion by water except in some of the valleys of the Caucasus, and too high for serious wind erosion, although some is always going on in the steppe region, and on the lower Volga one sees some characteristic wind and water erosion forms. The risk is there, it is intensified by the high proportion of grain crops—75 or 80 per cent. of the arable area—and by the increase of mechanisation. It was these factors that contributed largely to the ' Dust Bowl ' of the western States. But the lesson has been learnt. For the past twenty years of his life Williams—the son of a Russian mother and an American father, and always a great friend of England—advocated the use of grass leys, and in his well-equipped department at the magnificent Timiriazeff Institute at Moscow he set out some convincing demonstrations of what could be achieved. The value of his work was widely recognised and local applications were worked out. In the Gorki region Prof. Serebriakov developed rotations embodying this principle. On each of my visits to these various stations I have discussed with the agricultural experts this need for getting away from too exclusive cereal cropping and always found them completely agreed on the matter.

The recovery of output from the land will be greatly facilitated by the extensive soil surveys carried out in the last twenty years. Russian soil science has developed very much in the direction of soil classification and mapping, and soil surveys, often done in association with soil fertility studies. Fortunately, out of her vast natural resources Russia can supply the lime and phosphates shown to be needed.

But, unfortunately, the reconstitution of Russian agriculture will present terribly difficult problems. The rebuilding of the villages alone will require colossal efforts, but the peasants have done it before and will be equal to doing it again : local materials always have been used. The re-establishment of the crops will present even greater difficulties. If enough tractors can be made available and sufficient staffs found to work the old motor tractor stations that organisation can achieve much of the ploughing. But the other cultivations and the day-to-day work done by bullocks will be extremely difficult if, as we fear, most of the animals are slaughtered.

An even greater need is for supplies of good seed of suitable varieties. Drought has always been one of the worst enemies of Russian agriculture : indeed the yield of grain is usually more dependent on favourable rainfall and snow than on any other single factor. ' The Bolshevic struggle against drought,' said Molotoff, ' is the organised struggle on Soviet lines for the harvest '; this slogan hangs on a great scarlet banner in the central hall of the Institute at Saratov. Rainfall and snow are outside human control. The Russian scientists, like their colleagues in other countries, have selected and bred drought-resisting varieties of crops suitable for the various regions of the Soviet Union. The fundamental investigations of Vavilov and of Lysenko are well known here, and many have heard of Tsitsin's wheat crosses. But other plant breeders have done admirable work for the regions they serve, At Saratov Shekhurdin has produced varieties of wheat for the steppe regions of moderate rainfall. It would be a disaster of the first magnitude if the stocks of these varieties should be utterly destroyed; years of labour would be needed to raise and multiply them up again. It would afford in-

valuable help if American and Canadian agricultural organisations would take over pedigree stocks of the most important varieties, and keep them going, multiplying up those needed for seed, and holding the research material for the time when it will again be needed. This I think is one of the most urgent needs of the present situation.

The reconstitution of the livestock population on the farms will present greater difficulties. Russia has had to go through this before, and it brought her to the verge of famine and caused terrible suffering. From the high numbers of 1929 to the low records of 1933 the fall in numbers of all livestock was catastrophic. Then came reorganisation, and by 1937 a more contented spirit was noticeable among the peasants than in 1934. Two things had happened : the ' collectives ' had been given title deeds confirming their possession of the farm, and each individual member was to be given a cow, some pigs, and some poultry. And while in the towns the talk was of the new constitution, in the villages it was of the animals which had already begun to arrive. By 1939 the numbers were approaching the old level : many of them were owned by the peasants. Thus while the large-scale cropping was done collectively the livestock were largely owned privately by the peasants. This was of course a compromise, but it appeared to be working smoothly and it showed at any rate one way in which the livestock problem could be solved. Multiplication of animals, however, is a slow business and is never easy. First and foremost a supply of food must be assured, and housing for the winter. Then, as it is just as much trouble to raise a poor animal as a good one of the same race, a supply of good breeding animals is necessary. This will be one of the greatest difficulties in Europe after the war : the breeding stocks have been slaughtered with the rest. It is much to be hoped that some of the good animals in western Russia and the Ukraine are safe. Much time and energy had been devoted to selection and improvement, and it would be a tragedy if the breeding stocks were lost. If some of them could be transferred east of the Volga and multiplied there a quicker start could be made with repopulating the farms. In this re-establishment work, use will no doubt be made of artificial insemination, a technique for which was worked out in Russia ; used by competent people it allows more extensive service by good animals than is otherwise possible.

The most difficult reconstruction, because of the length of time involved, is that of the trees. The loss of the fruit trees is especially sad. Here the Russian and Ukrainian villages were improving : usually one finds some peasants interested in fruit-growing and knowing something about Mitchurin's improved varieties. The fruit trees go in the general devastation, but it would heighten the tragedy if the improved sorts should all be lost. It would be quite possible to keep them going in this country ; only buds are needed and these are easily transported : we could at any rate ensure the supply of material for propagation after the war.

All these problems of reconstruction will arise also in Poland, some of them more acutely because Poland has no hinterland where breeding stocks can be kept safe, and so far as we know none of the pedigree material was got out of the country. All is presumably lost. The burning of the village is no new experience : it forms the climax of one of Raymont's telling short stories, *Justice* ; even as late as 1938 there were peasant women who knew the incantations necessary for putting out a fire or at least preventing its spread. By 1921 Poland had been pretty completely devastated, but construction and improvement went on steadily. New varieties of crops, improved livestock, better cottages and buildings were increasing. We may safely assume that the Germans will destroy everything likely to help in the restoration of Poland, just as we may assume that the Poles, with their superior level of individual intelligence, will succeed in saving something. But at the end of the war Poland will be in urgent need of seed supplies, and here also one wonders whether Canada and the United States could not help by multiplying suitable varieties so as to provide stocks for restarting the farms.

The livestock problem will be even more serious than in Russia. The peasant's cow is the Polish red, preferred because of its tolerance of a hard life ; the peasants say you can feed it on brooms and it will still give milk—and you need to see a peasant's broom to realise what that means.

On the larger farms Holstein cattle are preferred. The breeding stock has in the past come from Holland, but most of their herds are probably slaughtered now. We have in this country some good herds and could supply the stock if the work were organised. Certain other of our breeds are very suitable for the continent, such as the Large White and Middle White pigs : supplies of these should be in readiness for restarting the farms.

The cutting down of Poland's forests is likely to have gone pretty far. In the north, in the region of the lakes and the sandy moraines, this will have the bad effect of causing the sand to drift, thus ruining the cultivated land. Fortunately, when peace comes the sand-fixing problem, though difficult, is not insuperable. If, as one hopes, the friendly relations between the Russians and the Poles continue, one may hope for a joint scheme for the draining of the Pripet marshes, which would add greatly to the productive capacity of Poland and of White Russia.

But whatever is done Poland will be in difficulties for some years after the war. The milk supply is likely to be very short, and the children's death rate very high. The peasants are unfortunately used to this, but it will be our duty to try to prevent it. Even in peace-time the village children looked very sickly in winter, though they picked up remarkably in summer when milk and sunshine and vegetables combined to help them. Yet it grieved me to be told in a Polish village that the opening of a milk factory meant death to some of the children, especially when I remembered that much of the butter made at the factory had come here, and we need not have had it, and could just as easily have got it from Australia or New Zealand, without that price having to be paid. Commerce takes no heed of such things, but one hopes that after the war they will count.

That is where more planning in our agriculture would help. We in this country have a special responsibility in this matter because we are the

world's chief buyers of agricultural produce. Before the war we imported 60 per cent. of the value of our foodstuffs. After the war we shall have to decide whether the imports are to continue on this scale, or whether we are to produce more at home, and if so how much more of the different items. The decision will turn on the general needs of the community and on the degree of insurance necessary against food shortage in the next war. We shall still continue to import, but we need not do it in any haphazard way : trading arrangements could be made with different countries whereby each could know what we were prepared to take from them and at what price. This would give stability of food supplies and prices to our people, and certainty to the peasants and small farmers of those countries with whom we deal. For years food producers have lived in constant fear of economic crisis and nothing has done more towards the frustration of agricultural science. If we could deal with that we should have overcome one of the greatest problems in the countryside.

Dr. Anni Noll
Family Health and Post-War Relief

THIS communication is based on experiments which were made at the Pioneer Health Centre in Peckham, to the medical staff of which I belonged during the period of its existence from 1935 to 1939. The task of the Centre was the study, the improvement and the development of the health of the family. Health was understood in its widest sense, comprising not physical health alone, but also mental and social health. The family is of obvious significance because the family and the home constitute the intimate environment of the individual, and in the family circle the habits are formed and the examples are set which are the basis of the principles to be employed in the wider public environment, and which ultimately are responsible for the cohesion of society. The importance of the family group in relation to science has been anticipated by the old-fashioned family doctor, and, indeed, the family provides the most favourable experimental conditions for the study of such subjects as constitution, diagnosis, nutrition, and research into the relationship between individual and environment. It is generally accepted that it is of importance to preserve the family as a unit and to use it as such in the reconstruction of the social order.

At present the progressive disintegration of the family, which is aggravated by evacuation, national service and other conditions, represents a problem which has to be dealt with as soon as the war has come to an end. The mere reunion of the members of the family will not be sufficient to reintegrate family life as all those would admit who have been engaged in social work already before the war. The provision of healthy living conditions and the improvement of the standard of general health are equally important.

Healthy living conditions can be obtained by careful planning of housing, transport, balance of industry, agriculture, food distribution, education and leisure facilities. The special science concerned with each of these subjects will have to contribute to the solution of the relevant problem.

How science can assess and improve the physical and social health of the population has been demonstrated by the experiments carried out at the Peckham Health Centre. Peckham is not a slum area but a district of south-east London where families representing an average mixed population are aggregated. Fifteen hundred families, corresponding to about 5,000 individuals, were carefully examined in laboratory and consulting room, with the following results. Nine per cent. were without any pathological signs and symptoms. Eight per cent. were conscious of being diseased and were mostly under treatment. The remaining 83 per cent. had some sort of disorder ranging from a simple anæmia to a malignant growth. The majority was not conscious of this fact ; a few, who were aware of a disorder, did not realise its significance and its possibly fatal complications, and consequently none of them was under treatment.

The families which were examined in Peckham represented only a small fraction of the population, but it seems justified to assume that similar results would be obtained if means were available to assess the health of the population as a whole. This assumption is based on the fact that the results of other group examinations are similar to those obtained in Peckham. The figures referred to above indicate, therefore, that four-fifths of the population are potentially ill and the question arises what can be done to prevent this large proportion from becoming actually ill. The solution of this problem is important not only to the individual but also to the family and to the State.

It is obvious that all those members of the population who are in a state of deceptive well-being ought to have professional attention at a stage at which the pathological process might easily be checked or even eradicated. But the individual, either not being conscious of the disorder or not being capable of judging its significance and its possibly fatal consequences, will not ask for professional advice. It follows therefore that a method should be introduced by which routine diagnosis is made possible. At the Pioneer Health Centre periodic health overhauls were carried out which dealt with every single member of the family. These regular examinations could not take place frequently and thus it was not possible to provide all the professional care the individual might have needed. A satisfactory solution was found by a system which enabled the patient to report any kind of disorder immediately at its onset. The idea of the experiment had been explained to the members of the Centre and none of them has been found to take ' neurotic ' advantage of this opportunity. In order to develop an efficient collaboration with the doctor the patient has to learn to become aware of health and conscious of disease at its earliest stages.

The observations made in the Peckham Health Centre emphasised the fact that the physiologically well-balanced individual is not healthy, in the widest sense of the term, unless full use of suitable opportunities of the environment can be made. The cultivation of a diverse environment is therefore as important as the care of the physical health of the individual. Health overhauls involved therefore not only medical examinations, but the social aspects of each member of the family and of the family as a whole were also taken into

account. The Peckham Health Centre established a well-organised social service, and also attempted to enlarge the limited, dull suburban environment by providing in the building itself a great number of possibilities for physical training and a great variety of leisure amenities. All the different activities of the Centre were organised by the members themselves, thus giving scope for the development of initiative and responsibility.

The service of the Peckham Health Centre has solved a number of problems which on a much larger scale are the problems of post-war relief. The distribution of Family Health Centres in towns and rural districts ought to be considered. They should be employed as outposts in the fight against illness and as research stations for the prevention of disease and the development of health.

Dr. E. Kodicek

Post-War Relief as a Starting Point to Post-War World Reconstruction

We must expect that after this war we shall have to deal with deficiencies of all kinds—in nutrition, in general preventive medicine, in housing, in employment, and in education. The entire problem has to be dealt with step by step, but with a final aim in view. Post-war relief cannot be separated from the much wider issue of post-war world reconstruction. All attempts based either on charity, or on improvisation, or on individual endeavours of the separate Governments, will be unable to deal adequately with the great tasks with which they will be confronted, as they were unable to after the war of 1914–18.

To deal with these problems, an efficient organisation of scientific experts and politicians is needed. This organisation should possess sufficient executive powers to implement the plans upon which it decides. If such an international organisation could concentrate upon a few main questions common to all people and all classes, desirable for all and wanted by all—namely, upon food, health, housing, employment and education—a common understanding and a common working plan could readily be laid down and the entire problem of post-war relief and long-term reconstruction worked out on these lines. Post-war relief as an integral part of post-war reconstruction is the most important issue.

Nutrition, especially in the occupied countries, suffers, and will suffer even more while the Nazis are draining all essentials out of them. In Czechoslovakia in 1937 a nation-wide survey of the state of health with regard to vitamin deficiencies was made and reported upon to the League of Nations. The most significant observation was that the frequency of deficiencies increased from the west to the east of the country. It is justifiable to assume that this frequency distribution applies in some measure to the whole of Europe. The present situation, and especially the development of the war, will change this distribution of deficiencies quite considerably. The rural populations may become better fed than the urban populations, since the former still have, to some extent at least, means of escaping the drastic measures of Nazi requisitioning. The occurrence of deficiencies will increase in the east as well as in the west, where the more refined type of diet calls for a greater variety of foods for a complete and healthy diet. We must expect therefore to meet new problems and new tasks. The distribution of food will be difficult owing to the lack of rolling stock, disorganisation of transport, etc. Taking into account not the minimum but the optimum diet necessary for maintaining health, groups of scientists from each country should undertake to put forward effective proposals for improving the standard of living and nutrition of their countries. Since the facts on which to work are already agreed upon, there should be no difficulty in doing this.

A further step is to plan which commodities will be the most necessary and which will be lacking immediately after the war. These foods will have to be bought and prepared for distribution. The central organisation with executive powers, in which politicians and scientific experts would work in collaboration with the help of the separate Governments, would take up these plans. It might mean a certain curtailment of their sovereign rights, but would in the end strengthen rather than weaken the democratic Governments. A stock of vitamin concentrates, for example, to be used and distributed in distressed areas, will have to be laid down, not as an act of charity, but as an efficient measure of reconstruction. The gain, both in the health of the people and in the growing feeling of confidence that the administration takes proper care of them, would be immense. We must not forget the possibilities of propaganda now in this respect. Communal feeding is another point in the post-war relief programme. Reorganisation of food distribution, of food-growing, and of exchange form other equally important aspects of the scheme.

It is surely not a pessimistic forecast to expect a probable outbreak of epidemics, unless efficient measures and plans have been made to meet them beforehand. Apart from all epidemiological considerations, which corroborate this expectation, we have to bear in mind the inevitable disorganisation of the health services in Europe. We might expect a temporary breakdown of medical supplies, and of therapeutic sera from European Institutes. All this needs to be considered in post-war reconstruction, immediately after the war as well as in the long-term programme of post-war relief.

Health services will have to be organised on the basis of State medical services, but will also have to pay regard to international as well as to intranational requirements. Such services demand to be directed by a central international organisation with executive powers. The immediate help needed after the war will include medical supplies of all kind. No less important, however, will be the distribution and training of doctors to be sent to the distressed areas. This would mean the institution of a scheme for interchange of doctors, not only for studies, but for work, exchange of supplies, knowledge and education. Such an organisation already in being could easily direct and deal efficiently with major epidemics. It could also cope with deficiencies occurring in a country whose own local medical services would be ineffective to prevent their spread.

Another urgent need of post-war relief will be the planning of housing. In countries which have been perhaps several times a theatre of war the need is evident. But elsewhere also the building of houses has stopped and there will be a great need for accommodation. Last but not least, we have to bear in mind that such a housing programme must have as its aim the improvement of the living conditions of the people everywhere. It is not possible to go back to the year 1938 ; nor is there any escape from the fact that the people themselves in a real democracy will demand their fundamental rights in deeds and not merely in words.

The effective utilisation of man-power immediately after the war must not be omitted in the programme of post-war reconstruction and relief. Its basic aim should be to secure creative work and a high standard of living for the people. An international settlement of this question would remove potential causes of discontent and unrest internally and internationally.

The most important factor I have left to the end : the need to establish understanding, and faith in the pledged word. We can restore this by efficient planning and by practical measures to be put into operation at the earliest possible moment. A few of the objects to be sought I have already enumerated ; they are common to us all, and a quick and efficient agreement is possible. The very force of the results achieved would do more than many words to convince and persuade people, especially the people of Europe, of the sincerity of our aim. A system of education, of democratic education, has to be initiated, an education based on international understanding utilising the positive and worthy sides of national life everywhere. This should be done by a central organisation. Education after the war is a first-class relief programme.

Scientists of all nations can and must contribute to this end. The four great powers of the future, the democratic powers of the United States of America, Great Britain and the British Commonwealth of Nations, Russia, and China, I am certain, will feel their responsibility and necessity of taking the lead on these lines. Thus will be formed a crystallizing centre to which all Europe can contribute its potentialities. A real constructive aim of this kind will inspire the people in Europe and strengthen them in their fight.

Mr. E. Wallach.—The Regulation of the Metal Industries on the Cessation of the War

THERE are two schools of thought concerning the future of metal and many other industries after the war. One foresees fighting one against the other because many manufacturers may think they can use for the production of peace-time goods the enormously expanded factories created only by the power of destruction for the sole purpose of producing destructive goods. The other school has not nearly such a pessimistic view. If we follow the sensible words of John Stuart Mill : 'The liberty of each limited by the liberty of all,' then I think we may expect quite reasonable conditions after the war, even in the expanded metal industry.

All the enormous German and Italian metal factories, including those erected and expanded by them in the occupied countries, will prove to be most useful as melting material for foundries. The metal factories of the allied countries must also disarm, but in a different way. Enormous reserves of metal factories must remain as a protection against the repetition of all that we have lived to see. It may be that this reserve would be much greater than that necessary for the home and export trades.

We have to build up in time a strong opposition to the pre-war methods of the big factories which exported *à tout prix* if they could not find an adequate home market for their output. What should be the task of every manufacturer who is worthy of the name? Not to utilise greater masses of stone and steel, nor to think of his own profit only, but to consider the needs of his employees and his fellow competitors.

Some years ago I told my English, German, Swiss, Swedish and other competitors that the form of brutal price-cutting and hatred creating competition which then existed in our trade must be replaced by a kind of international price agreement, cartel, and so on. My chief English competitor immediately took up the idea of co-operation, with the result that, in a relatively short time, the manufacturers of seven countries made quota and other arrangements all over the world. If such a procedure was possible for one industry, surely it would also be possible for many others. In this country are economists with great knowledge, industrialists with great experience and men of standing from various European industrial countries who could form an advisory council. The execution of these ideas from the theoretical and from the practical point of view is far less complicated than many may think. I would like to mention some of its advantages.

(1) The avoidance of economic wars and worse still of the real war which inevitably follows.

(2) The avoidance of too much fluctuation of labour because international quota arrangements give some guarantee of a constant export employment for a certain period (I hardly need remind you that long-lasting unemployment was the main cause of the rise to power of the Nazis).

(3) The avoidance of violent price fluctuation with its well-known consequences.

(4) The easy procurement of adequate funds for important research work.

From whichever point of view you deal with such proposals, if you want a planned economy, if you want price-control in the interest of the consumer, if you want some guarantee of more regular employment, if you want a limitation of competition and therefore a higher profit, there seems only one way out for the metal industry and for most other industries : international co-operation.

Mr. H. E. Norman, O.B.E., J.P., chairman of the British Federation of Social Workers, continued the discussion of social aspects of post-war relief.

Dr. Hugh H. Smith.—The Rôle of Epidemiology in the Post-War World

AMONG the multiplicity of urgent problems which will face the post-war world that of health will be

of prime and pressing importance. In no field will the ' good neighbour ' policy be more necessary. The great advances in rapid transportation, with the resulting development of trade routes, is turning the world more and more into one community. Since no effective barrier can be raised against the entrance of many infectious diseases, each nation must concern itself with the health conditions of all other nations. The function of the epidemiologist in a broad sense is to study the natural history of disease in order that the weakest link susceptible of effective attack may be found. Since in the post-war world there will be many calls on the money available for relief and reconstruction, it is imperative that funds allotted for improvement of health conditions be spent as effectively as possible. This can only be done by careful scientific investigation of each problem to be attacked. Workers properly trained in the principles of epidemiology supported by essential laboratory facilities must be employed in the field. International effort must be co-ordinated and information be collected by central agencies for distribution to all.

While the exact effect of poverty, with its resulting overcrowding, malnutrition, worry and strain in the spread of disease, is not understood, there can be no doubt that these conditions do have a deleterious effect on the health of the community. The great Powers emerging victorious from this war must share for a long time the responsibility of those nations whose health organisations have been broken and disorganised. This sharing of responsibility for health among nations is by no means an act of charity, but, as is true in smaller communities, is of vital concern for the protection of the health of each individual member of the community. President Roosevelt has proclaimed ' freedom from want ' as one of the fundamental freedoms of man. That means the right to live in conditions compatible with good health. There should be no property qualification for good health. The rôle of epidemiology should be to furnish the information and techniques wanted to make a really healthy world possible.

Dr. Zing-Yang Kuo
Post-War Reconstruction in China

CHINA is destined to become a major power in world politics in the future. She may become a major stabilising factor in the world order or a great menace to international peace. This will depend on how she is reconstructed after the war.

It is proposed that in China's national reconstruction a well-planned economy with the full co-operation and collaboration of Great Britain and the United States should be worked out so that China will be enabled to promote her internal stability and prosperity and to contribute her share to international peace and order. In working out such a programme the following points should be adopted as guiding principles :—

(1) China should modernise her industry and agriculture for the purpose of improving the standard of living of her masses rather than for foreign trade.

(2) The United States with the collaboration of Great Britain should agree to provide sufficient financial and material aids to China for her national reconstruction without provision for commercial and financial benefit in return.

(3) China should agree to export only those products which will not lead to unnecessary and undesirable competition for the world market.

(4) Great Britain and the United States and other nations should agree not to export, or to export only a limited quantity of, those articles to China which may tend to hamper the development of her industry and agriculture.

Only by a programme such as this can China hope to avoid the evils of capitalism, Nazism, Fascism and Japanese militarism and the mistakes of Communism. This programme is in accord with Dr. Sun Yat-Sen's three principles and with his plans for international development of China.

The United States and Great Britain should grant China full partnership in the present war and in the post-war reconstruction, and should cease to treat China merely from the standpoint of diplomatic expediency. New China calls for a fundamental change in the mental outlook towards her and the Far East on the part of Great Britain and the United States.

SCIENCE AND THE WORLD MIND

SUNDAY, SEPTEMBER 28 : AFTERNOON SESSION

CHAIRMAN : MR. H. G. WELLS

The Chairman [1]

WE are very much up against time to-day. At this present session I had assumed that there was to be a real discussion (give and take) of the World Mind and the rôle of this Division in relation to it. Accordingly I prepared an address in which I did my best to summarise the whole problem of the world mind and to bring its many divergent factors into some sort of general scheme of action to which the British Association could lend the weight of its authority. But there is no time to read this address. I propose now to run over the chief ideas in it and so clear the way for those who wish either to endorse, qualify or disprove the propositions I have done my best to bring together. My primary idea was that there is no orderly world mind at present, but only a world dementia, and that it is the

[1] The material here printed is the spoken abbreviation of a longer address prepared for the Conference by Mr. Wells, and subsequently published by the New European Publishing Co., 29 Great James Street, London, W.C. 1.

business of scientific men to pull together this confusion and prepare a working conception of organised will and knowledge upon which mankind can go. It has been done, and if this great international of men of science cannot do it, nobody can do it. This gathering gives us an unique opportunity, that may not recur, to work out this co-operation in human leadership.

The essential evil is lack of co-ordination. All sorts of fine ideas and constructive experiments are going on ; but where there are contradictions we—and by ' we ' I mean the world of science in the widest sense as it is represented by this Association—have not yet got together in any effectual way to work them out. We are too individualistic. We do not listen to one another in order to get to a common understanding. One man talks about this aspect and another concentrates on that ; and the algebraic sum of our directive influence upon the world is inconsiderable. Cannot we get this great task put in order before we disperse ? I think Sir Richard Gregory has already shown that to do this is a possibility ; that it is possible to do something effective to fix our maximum agreement, and in this afternoon's meeting we may underline and get a good deal out of his suggestion.

We had a good deal of discussion behind the scenes before we got this problem into shape. When I told our organisers that I wanted to open our deliberations with a paper that might occupy three-quarters of an hour or more they told me it was impossible. Since my address was designed as a synthesis and summary I protested with considerable emphasis. They were working under novel conditions and under considerable stresses, but it seemed to me they were in danger of producing exactly the sort of thing against which my paper is aimed : that is to say, unco-ordinated statements and declarations that would take us altogether nowhere. I found our President in complete agreement with me on this point. He agreed we should overlap ; we should waste time in overlapping. We might contradict each other, and there would be no time to clean up our differences. So we came to the compromise of mimeographed copies. Later this address of mine may be revised and reprinted, but it will certainly lose most of its value if it is not reprinted with the substance of the subsequent discussion, and as leading up to Sir Richard Gregory's resolution. Very few people want to know what I, as an individual, think about the World Mind ; but all the world is prepared to attend to a discussed and approved digest of what may be the deliberate opinion of the scientific world.

I will give you the chief points of that address upon which I think it is high time we came to some definite conclusion. In an introduction I give the reasons that I regard as insurmountable for looking forward to a federal control of the air, of transport generally, and of the staple natural resources of the world. I show the need for a fundamental world assertion of human rights, and I dispel the idea that this involves any destruction of other languages or of local differences under the shelter of that federal union. I cannot repeat my arguments here —they are there in the address. Arising out of them follows the practical necessity for a series of definite scientific decisions.

First, it seems to me that there must surely be a federal world language to clothe the thought of the world. We ought to be clear about that and about its relation to the diverse languages in use. I state what I believe to be the acceptable view up to date, and you have it in the address. But if my argument is not final and definitive then, following up the suggestion of Sir Richard, cannot we set up a small committee to hammer out that unsettled issue ? I say a small committee, and I mean a committee that would do real hard conclusive work and deliver its findings in a definite time.

Secondly, if it is agreed, as I think we are inclined to agree, that English is not to be a world language but is the best structural basis for a world language, then it is time we got spelling and phonetics out of the chaos in which they remain to-day.

Thirdly, I raise the question of the meaning of words and the importance of what are called significs and semantics in modern education. We want people all over the world to supplement the analysis of sentences by the analysis of meaning.

Fourthly, I go into the question of the storage of knowledge and ideas, the memory, that is to say, of the World Mind ; and I call attention to the valuable work in documentation that is being done by the International Federation for Documentation which, by the by, was meeting in London last Friday. This I have correlated with the vast possibilities opened up by micro-photography.

From that I pass to the question of a World Encyclopaedia, a digest of existing knowledge. Manifestly, if ' world mind ' is to mean anything more than airy nonsense it involves the creation of a World Institute of Thought and Knowledge which will be continually accumulating knowledge and presenting it in special digests and a general digest, which latter will have to be the basis of a world educational system.

I point out that the only thing that begins to be worthy of the name of a modern World Encyclopaedia is Monzie's gallant effort

which France, Republican and radical France—may she live as France for ever—was producing before her temporary submergence.

I go on in general terms to sketch a world education based very largely on such a broadly conceived encyclopaedia. That gives us six practical associated enterprises necessary to implement any sort of world mind or world community. Until we, the scientifically enlightened people, set about bringing that into existence—and only we can set this thing going—the world mind will remain the entirely incoherent crazy thing it is at the present time. We have to stop tootling away at our separate little notions, and we have to work out something definite and authoritative. That is the basis I offer for your present discussion.

Since my address was written this Division has been meeting for two and a half fruitful days. I have been happy to hear a number of points in that address anticipated. Bernal, for example, used phrases so identical that for the moment I thought he must have read it. But we have had a lot of talk together and the phrases were ours—his just as much as mine. If I had my time over again I should certainly have modified my address in the light of several important communications to which we have listened. I think a number of us were profoundly impressed by Sir John Orr's attack upon the world problem as one of nutrition. That was a new angle. He was illustrated, so to speak, by several papers of which I found Sir John Russell's this morning one of the most vivid. Sir John Orr has the lucidity, simplicity and power of the scientific mind at its best. Of all the admirable papers we have heard, his, I think, was the freshest and most valuable. You need no forcible feeding for human beings, he told us : put the best within reach of them and they will take it. His thought evidently did not end with material food.

Dr. Jennings White has been writing some excellent sense about education. In this respect, at any rate, he says there is no difference between mind and body. Put the stuff fully and abundantly before the naturally curious and intelligent healthy human being and there is no need for the unattractive cramming that we have called education. He has adopted the old medical term 'eutrophy' to replace schooling, and I confess I find it a most attractive word.

Another thing I have learned from these past three days, and one which I should have modified my address to include, is the power of material necessity over human activities, prejudices and traditions. One material necessity that has dominated collective behaviour everywhere is the necessity of controlling rainfall and conserving water power. The Dnieper dam is a very present tragedy in our minds. But every form of Government has to dam. Communist Russia is at one with individualist America, and when Lord Hailey—who has a paternalist British mind, and seemed to be quite unaware that the British Empire was broken up by the Statute of Westminster some considerable time ago—when Lord Hailey surveyed Africa and our responsibility for Africa, the same physical necessity was apparent. It is plain from the excellent account we were given of the Tennessee Valley Authority that the dam—that is to say, technical science—revolutionises human life. It was interesting to hear Professor Alvin Hansen arguing that for all that elaborately protected financial profiteering in houses, for example, would still go on, but I think most of us agree that Mr. H. P. Vowles, in his excellently documented criticism, took all the probability out of that. Man, if I may say so, is going to be dammed for his own salvation. So you see, you can approach the world problem from a number of separate points according to your mental temperament. The protection of the world from any more blitzkriegs, for example, is the line of my approach ; but you can also approach it from the point of view of conserving natural forces, or from the point of view of nutrition. If you follow up your start, after the fashion of a good scientific mind, arguing out every implication and never wandering off into side issues we meet at last, all of us, upon the same human outlook. I have seen various symbolic figures representing science—mainly they were very attractive ladies very carelessly dressed. But for my own part what I would like to have as a symbol of the scientific mind is a bull terrier which never loosens his grip except to improve it.

But I, at least, must not become discursive. It is our business to be practical. It is our business to join things up, and so I welcome Sir Richard's idea of appointing special committees to consolidate what has been said in this and previous discussions, and to present a report giving the matured scientific view upon these matters, provided only that these committees are not too large, that they set to work at once, and that they concentrate upon producing their report.

In my address I refrain from all idealistic or imaginative utterances. It is a practical survey of current ideas without the least ingredient of originality. From first to last it is an abstract.

Since the days of Buddha and Confucius there have been very many noble and beautiful things said about freedom, truth, and the equal brotherhood of man. We are,

I am told, not always on the best authority, saturated with these ideas, and our business is to give them a material body. That is a more difficult matter. The practical liberation of the world mind began not with any of these great aspirations. It began with the invention of paper and of printing from movable type. Invention and discovery are the true liberators. That is our sort of work and the less we dilute it with rhetoric and the less we wander away into the wilderness of disconnectedness the better it will be.

Prof. Lancelot Hogben, F.R.S., spoke on the proposal of international language planning made by the Chairman.

Mr. J. G. Crowther

The Education of the Public

EDUCATION of the public to-day means dragging out into the realm of consciousness the forces that are paralysing human intelligence, and making nations commit suicide. During the last twenty-five years the state of whole classes of men, and then of whole nations, has been reduced to defenceless stupefaction. We have seen the flat denial repeated for years that Germany was re-arming. This has been accompanied by various forms of pacifism, appeasement, isolationism, phoney wars, and phoney lulls. The automatism of the present epoch seems to be without parallel in history. What has to be done is to destroy this automatism, and enable mankind to act according to conscious, intelligent, self-realised principles. This is why a set of guiding principles, which can be simply, clearly and inspiringly expressed, is absolutely necessary if we are to master the present situation, win the war, and win the peace.

What is the meaning of the contemporary automatism of which I have spoken? Why do nations, in very different situations, and with very different forms of governments, make exactly the same political errors? This must be due to some underlying cause which is outside the usual range of political forces. I think it is possible to say what this cause is. It is lack of adaptation of social forms to the possibilities of technique. When advances in technique put certain possibilities within the reach of humanity, these begin to be achieved. The more consciously they are recognised, the less pain is suffered in achieving them.

The great possibility that modern science has placed within the reach of humanity is the unification of the world. It arises from the invention of the telegraph, radio, steam engine, aeroplane, and a hundred other innovations. The possibility is there, and is virtually inevitable. It will be realised by some human agency. The only question is, will it be carried through by criminals or by law-abiding citizens? Men of good will cannot control this tendency of history if they do not understand it. I do not think it can be understood without some knowledge and appreciation of science.

According to our existing theory of government, which was inherited from the ancient Greeks and still dominates our conceptions, scientific knowledge is not a necessary qualification in statesmen. The principle that men who rule a technological civilisation need have no knowledge of science is still accepted. Linked with the same idea is the belief that a man ignorant of science can yet be accepted as educated.

Owing to the survival of these old views, no doubt suitable to the conditions of a slave civilisation, we find ourselves governed at the most critical moment in our history by a House of Commons which does not contain, as it never has contained, more than a very few members who are or have been working scientists. Is that rational, and has it got any sense or relevance in the present situation? What is so sickening is that some, at any rate, of the possibilities of modern science have been understood better by uneducated political criminals than by the men of good will who have been intellectually castrated by an education centuries out of date.

At the same time, hope is raised by the fact that men uneducated in the conventional sense may show a better grasp of the possibilities of science than those who have been blinkered by an unsuitable training. It is possible that the skilled craftsmen of the community will grasp more easily the implications of modern science in society. These are the men who make and fly aeroplanes, tanks, guns, and all the instruments of technological civilisation. On the basis of their practical knowledge, it may be possible to raise in this country a wave of scientific passion which will bring into power scientific statesmen, and release a burst of scientific discovery and invention new to the world. The British people must understand the greatness of their own scientific achievements, and the mighty power that resides in their genius. Are the people who produced Harvey and Bacon, Boyle and Newton, Faraday and Maxwell, Darwin and Huxley, Thomson and Rutherford, to be defeated for lack of scientific weapons? The potentialities of the British people are enormous. But these potentialities will have to be realised if we are to survive. Britain is a small country, and her population is little more than half that of Germany's. And the Germans have fostered their scientific abilities.

I would like to show a graph of the Nobel awards in science (p. 97).

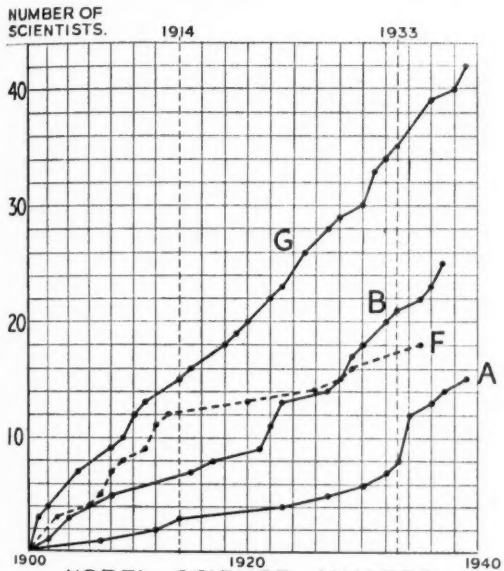
It will be noticed how greatly the German total exceeds that of any other nation. Also, it is notable that the rate of awards to German scientists was not slowed down either by the war of 1914 or by the accession of Hitler to power. This suggests that Hitler's persecution of intellectuals has not diminished German scientific power as much as is supposed. What effect it will have in twenty years' time is another matter. But for the present, German applied science, and a considerable part of pure science, can continue almost unimpaired in strength while it can still live on the technique achieved in pre-Hitlerite Germany.

The graph of the French performance reveals a remarkable turning point in 1914. It suggests that French science was smashed by the war of

1914 and never effectively recovered. This helps to explain the fall of France. The aim of the Germans in 1914 was to smash France. We see now that while they appeared to lose the war, they had in fact won their aim.

On the other hand, British science leapt ahead after 1918. This is probably attributable to the formation of the Department of Scientific and Industrial Research in 1916, the increase in endowments of the Royal Society, the formation of the Imperial Chemical Industries and the general increase of expenditure on research. This was accompanied by a good deal of modest and almost unconscious planning.

The American curve has begun a sharp upward



G :—Germany (including Austria).
B :—Britain (including the Dominions).
F :—France (including the French Empire).
A :—United States of America.

trend recently. It is evident that the Americans are beginning to reap the intellectual dividends from their vast expenditure on science.

It is noticeable, too, that the slopes of the curves, or rate of reception of awards, have recently been about the same in Germany, Britain and America. Germany has received about three times as many Nobel prizes for chemistry as any other nation. Fortunately, the present conflict is more a physicists' than a chemists' war. Another feature of the Nobel awards is that since 1918 British medical scientists have been receiving the laureate at a greater rate than Germans. The belief in the superiority of German medical research is a myth.

It seems to me that these curves help to explain the tremendous scientific and technical strength of Germany, the collapse of France, and our own power of recuperation, which has surprised the world. The fact is that the scientific core of British skill is not unhealthy. Our business is to make it expand and grow as rapidly as possible. We must explain these facts to the British people, for it is only they who can insist that an adequate use of science be made. Science must be made a popular interest and source of pride.

In Germany science was never a popular interest. It was consciously fostered by the governing classes as an instrument of national aggrandisement. Alexander von Humboldt, Adolf von Baeyer, and many others have left statements which explain this. We have seen what happens when science and technique are developed without popular understanding and backing. We must see that that does not happen here.

Fortunately we have some points in our favour. I think the British people have, on the whole, by far the best popular expositors of science. They have produced the greatest popular expositor of science known to history. He is Mr. H. G. Wells, who presides over us to-day. Then there is the long roll of great investigators who have felt it their duty to expound their work. In this place, the names of Davy, Faraday and Bragg especially come to mind. Why should we have such a galaxy of expository science writers? I believe it is a product of the British tradition of freedom and democracy. In this country, in contrast to Germany, it is felt by great scientists that the public, who support them, have a right to know something of what they are doing.

In the modern world, popular knowledge of science is a condition of the survival of civilisation. The democracies cannot win unless their scientific genius is inspired and released. They have a spendid collection of men qualified to help in this. Why not make full use of them, and create a scientific instrument of democracy before which even the dinosaur of Nazism will collapse in impotence?

Prof. Max Born, F.R.S.
On the Teaching of Science

My subject is the teaching of science with respect to the general problem of establishing a new world order. There are two aspects of my subject: the technical question how to teach science efficiently in order to produce specialists of a high standard; and the wider question how to organise education in such a way that science may occupy its proper place in the minds of men. It is this second point which is the concern of a meeting like the present one.

If science is to be taught in a way appropriate to its place in the world order there must exist a clear idea of this order and of the part which science has to play in it. This is a question of economics and politics, guided by principles of philosophy and religion; a question outside the competence of science, even utterly unscientific. For science deals with facts and their interpretation. Its power of predicting unknown facts and future events depends on universally accepted principles and laws, and on the knowledge of a sufficient set of data. Where are these principles, where the data in the problem of world order?

Consider, for example, two books by eminent writers which both start with a definition of 'progress' as a foundation for their deductions. One of them, *Man Makes Himself*, by the Edinburgh prehistorian Gordon Childe, suggests a quantitative definition as the only scientific one, namely the size of the population in a given

civilisation. The other, *Ends and Means*, by Aldous Huxley, defines progress by the words ' non-attachment ' and ' charity,' in an obviously unscientific way. I am not going to reject Huxley's definition *a priori*, as I consider the question of definition of progress not as a scientific one, at least at present, and as I feel that the world badly lacks non-attachment and charity. It is the decline of these powers of the soul which indicates the barbarism of our time. For practical purposes we all agree about the direction, not which the human race will take, but which we would wish it to take : peaceful co-operation, a maximum of freedom for the individual combined with the optimum of organised efficiency in production, economic and political security, as formulated in the great Atlantic Charter of our leading statesmen. How can science be taught in order to fit into this order ?

My first conviction is the independence and freedom of scientific thinking. There are two extreme and opposing theories about the part of science in the life of society. Orthodox Marxism considers it as a product of social circumstances, produced and directed by social needs, without any other purpose and justification than the systematic development of practical methods for using natural forces and accumulating wealth and power. The other standpoint is that of the individualist ; science is an attractive and noble occupation, amusing and sometimes exciting, and its purpose is solely the satisfaction of those who are enjoying this kind of hobby. Here we have a second example of two contradictory definitions violently defended by groups of scientists themselves ; represented for instance by Bernal's *Social Functions of Science* and Hardy's *A Mathematician's Apology*.

As a theoretical physicist I am not worried much by these apparent contradictions. A most important contribution of modern quantum theory to the general principles of natural philosophy is Niels Bohr's principle of complementarity. Bohr himself has immediately stressed the scope of its application to other subjects and applied it to problems of biology and psychology. I shall try to explain it by the example of the propagation of light.

There are two theories of light, the corpuscular and the wave theory. Newton's particle theory was generally accepted in the eighteenth century but dethroned by the discovery of interference and diffraction, which are characteristic features of wave motion. After a hundred years of uncontested rule of the wave theory there came, however, new discoveries, such as the photo-electric effect, the Compton effect, and others, which could only be explained with the help of particles : a dilemma as bad as anything in moral and practical philosophy. The solution given by Bohr is strange, measured by traditional scales, but most attractive to those who are convinced that methods of thinking have to be adopted to the empirical situation, that new facts need new conceptions. The new theory of light, and that of a more general class of physical phenomena, quantum mechanics, is a logically coherent system in which the two historical theories of radiation, trains of waves or showers of particles, are limiting cases suitable for the description of particular aspects of the phenomena, two different languages telling the same tale, not contradictory but complementary.

To understand this the meaning of the words ' particle ' and ' wave ' must be critically analysed. The definition of particle includes the idea of action concentrated in space and time to a point practically without extension. A simple wave, on the other hand, can only be defined as something filling an extended part of space and time, large compared with wave length and period, practically infinite. Both pictures are related by the fundamental law of quantum theory well established by innumerable experiments, that the energy of a particle and the frequency of the corresponding wave are proportional. This leads to an unambiguous way of describing one and the same experiment with particles or with waves ; it is true that this description is of a statistical character and does not conform with the traditional conception of causality and determinism. But something has to be sacrificed to save a desperate situation, and the success of quantum theory in predicting new facts has fully justified this operation.

If theoretical physics, which is rightly considered as a most refined branch of science, leads to such a situation, why should not something similar happen in less developed fields ? I suggest that the two definitions of progress, or the collectivistic and the individualistic justifications of science, are not contradictory, but complementary, and that a wider and superior view is both possible and necessary.

There is an attractive book by our chairman, entitled *The Sleeper Awakes*. It is the story of a man who sleeps for centuries and awakens in a strange world of days to come. I ask the chairman's permission to borrow this title for a greater drama which nobody can write, but in which we all play a modest part, being simultaneously actors and audience, the drama of man's progress. It is a sleep indeed, out of which we are slowly emerging. A few hundred years ago we found the simplest laws of mechanics, optics, chemistry, we saw the satellites of Jupiter, the first microbe, then we discovered the cell, and quite recently we photographed tracks of atoms. A few of us are awake enough to register all this and to show it to our neighbours. Then these people look around and are angry, for their dreams seem to them more pleasant than reality. Many turn over on their side and go on sleeping. But others rub their eyes and look around, and they find things not so bad, even beautiful and fascinating beyond anything dreamland could offer.

But I shall not overdo this parable. What I wish to emphasise is this : if science were merely a tool of material progress man would be just an animal, but more unhappy because of the increasing complication of his life : working in order to feed, and feeding in order to work. Science is more than that. It is man's consciousness, his collective property of knowledge about the world in which he lives. It is the decisive factor which distinguishes man from the brute and which gives him his dignity.

This formulation is an attempt not at a compromise between Marxian dialectics and individualistic idealism or any other intermediate

philosophy, but of a more elevated standpoint from which these extremes appear as complementary aspects. For we can eliminate from human affairs neither the collective nor the individualistic aspect, any more than we can deal with radiation without using the notions both of particles and waves. Science, and art as well, are products of single brains and cannot be severed from the individual. But they are also parts of civilisation, which is a collective enterprise, produced by collaboration and utilised for the community. We have to reconcile the individualist with planning, which is unavoidable, and the socialist with freedom of research, which is imperative. Let us agree that science and art are collective property which the individual shares and enjoys according to his powers. Let us consider ourselves, scientists and artists, as custodians of this common wealth. And let us insist on the dignity of science as an independent and free activity, solely devoted to the task of discovering the structure of the existing world.

I have dwelt on this abstract consideration because I need a fixed point for discussing the problem of teaching. One cannot formulate a programme of teaching without having some definite conception of truth. I reject the idea that truth depends on the economic situation of society or on the taste of an individual. Scientific truth can be veiled or concealed for a time, but it always emerges in due course.

The greatest enemy of science is therefore systematic untruth, carried by propaganda. The events of the last years have shown that, just by the use of scientific inventions like wireless, it is possible to condition the mind of the younger generation of a whole people for any purpose, good or wicked. This cannot be counteracted by prohibiting technical inventions, but only by insisting on truth as the fundamental condition of society. Here science is an important factor in education. For reliability and truthfulness are the first things a scientist has to learn.

I have been asked, how it is then that German scientists have submitted so easily to totalitarian ideas, although these acknowledge science only as a political, economical, and military tool. The answer is connected with a dangerous attitude found not only inside the totalitarian state. It is the ability of some men to divide their brain into watertight compartments, without interaction and without the mutual relation of complementarity which produces a higher unity. The worst form of it is the narrow specialist who is abundant in Germany. The average German scientist is extremely efficient in his field and knows this. But his self-confidence fails him completely outside his domain. He believes that there are experts for everything who know better, and he is happy if he can transfer to them the responsibility of action. In these conditions a self-appointed expert in politics, a Führer, will find little opposition. The result is well known. It is not due to a specific failure of scientific education but to a lack of democratic tradition and training in civil virtues.

The specific truth contained in science differs in some degree from the truth in other subjects which form our general education, history, classical and modern languages. I cannot give a philosophical description of the difference, and I do not wish to establish differences of value, but to stress again the complementary character of the arts and science. Even inside science there is no unity of subject and method. Who of us knows more than a small section of the whole? Yet the fundamental attitude of all of us will be very similar, and it is this attitude which we have to preserve and develop by teaching: the attitude of detached observation, of reserved judgment, of quantitative estimate on the one hand, of keen imagination and fearless generalisation on the other. There is no question that the average man is still far more attracted by the tale of man's deeds, sufferings, and passions than by the objective record of natural phenomena and laws. Our task is not easy: we have to compete with the greatest writers and poets, and with the most fascinating and exciting stories.

I reject the suggestion that this formulation of our task is wrong, that we have simply to communicate useful knowledge, like reading, writing, and arithmetic, only on a little higher level. That is, in fact, what scientific education generally is to-day. And that is the reason that science has not had its proper place in our civilisation, that it is not used to its full extent for making life richer, in matter and mind, but for senseless destruction.

Science is one of the great adventures of the human race, just as fantastic and exciting as all the tales of heroes and gods, nations and states, constitutions and wars, ever written by historians and poets. That is my conviction, and I think that science should and can be taught in such a way as to convey some inkling of this spirit to the youthful mind. Science is not simply a tool to be used by those in power, for material interests.

The problem of actually teaching science as part of general education is extremely difficult. It presupposes the proper training of teachers, the writing of textbooks and the devising of a syllabus. The last problem is the easiest. Cosmology, the stellar universe, have always fascinated the human mind, and the stages of its development—Babylon, Egypt, Ptolemy, Copernicus, Galileo, Kepler, Newton, Einstein—are marks in the history of man, coinciding with high tides of culture in general. The characteristic feature of our modern times is the analogous development of the microcosmos, the world of atoms and sub-atoms in physics and chemistry, of cells, nuclei, and genes in biology. In modern education these things should not be given as mere facts, but as material for teaching scientific methods, experimental and theoretical. The analysis of a primitive conception such as ' length ' or ' distance ' has a high pedagogical value as it reveals by a simple example the continuous change and adaptation of a notion to the empirical situation. One cannot measure distances of stars or atoms with the ruler; the whole of physics has to be applied to obtain a figure which to the outsider seems to be a trivial geometrical result. On a higher level are the Newtonian conception of mass, the Daltonian conception of the atom, Faraday-Maxwell's ideas of field. By a proper choice of the subject it should be possible to convey to the average student at least some idea of modern generalisations, statistical mechanics, relativity

and quantum theory, which touch the old and famous philosophical problems concerning space and time, matter and ether, cause, chance and probability.

There are many books presenting science in an attractive way. But we need something more solid, intermediate between these books ' for the million ' and the textbooks for specialists, filled with the spirit of understanding for the complementary interaction of individual and society. It will take years of experience to develop the proper type of textbooks and an efficient syllabus for schools and universities. But I think that the aim to make science an integral part of general education is attainable. I hope you will not share the pessimistic definition of education, given by a man formerly holding a high position in the administration of education in Scotland : ' Education is throwing artificial pearls before real swine.' If this were true all our efforts would be in vain indeed.

I have the impression, however, that there is too much book learning, too much examining, and a lack of continuity between the lecture-room and actual living science—not to mention the nuisance of old-fashioned units. My own subject is perhaps a bad example, as it is at present in a belated state of adaptation to modern demands. In this country it is still called applied mathematics and considered as an appendix of pure mathematics. In fact it has become, a generation ago, not only one independent science, but a group of such. Most of the experimental sciences have developed a mathematical part which by sheer power of growth tends to become independent, for the simple practical reason that very few men are able to be experts in experimental and theoretical work at the same time.

In this way, by personal disunion, theoretical physics has grown into a separate science, and in chemistry, in mineralogy, and even in genetics similar tendencies are observable. On the other hand, the practical applications of mechanics, formerly parts of physics, or appendices of mathematics, such as elasticity, hydrodynamics and aerodynamics, have become extremely important to industry and defence, and grown beyond all bounds. In Germany and the United States they are acknowledged as independent subjects ; the momentum of technical progress in these countries is partly due to this circumstance. On the other hand this specialisation is connected with the weakness of the German scientists as a class. This danger can be counteracted by developing the contribution of science to general education in the way I have suggested. Concerning the branching off of theoretical departments, we are here in Great Britain in a state of transition. My department has at last succeeded in changing its name to Mathematical Physics, still with Applied Mathematics in brackets ; and the syllabus is going to be transformed according to modern requirements. I am sure that in other subjects there are also fossil remnants to be replaced by modern forms.

Concerning examinations I have found that there are too many and that they occupy far too much the mind of the student, who seems to work not for acquiring knowledge but for a degree, and after that for a higher degree. This produces the wrong atmosphere for developing scientific enthusiasm. But I am reluctant to criticise this system, for I have not gone through British education and never passed a British examination, and I have no definite suggestion of an alternative method for selecting able students and rejecting bad ones. If all teachers were perfect, wise and just, the ideal would be to leave the decision about the advancement of the pupils to the teacher's free judgment, based on intimate knowledge of their daily work. When I was a student in Göttingen forty years ago, this was still possible and successful. But modern mass production excludes such personal methods and requires the use of objective scales. Yet some modification of the mandarin system seems to me desirable.

The last thing I wish to mention is the tendency to separate teaching and research. It is unavoidable to some degree, since modern experimental technique needs highest specialisation which is incompatible with university teaching, quite apart from the question of expenses. Therefore research laboratories will spring up more and more. But it would be a calamity if research at the schools of learning were strangled. Teaching of science can only be successful in intimate relation to research. The research institutes should therefore be attached to universities and technical schools. One should never build an institute for a purpose and try to fill it with able men, but take an able man and build an institute around him. For man's brain, energy and devotion are the deciding factors in science as in all other fields of human activity.

Dr. Joseph Needham

Aspects of the World Mind in Time and Space

THE view of the world which modern science has disclosed to us embodies what at first sight seems a curious contradiction. The collective work of physicists and chemists, of astronomers and engineers over more than two centuries has given us, among certain other fundamental natural laws, the great generalisation known as the law of entropy. The universe, or at any rate its parts nearest to us, are continually passing from more improbable to more probable states, free energy is constantly decreasing and entropy (or bound energy) increasing, and it would seem that we are slowly approaching a condition of thermal equilibrium in which no further utilisation of energy can occur. They expound this as meaning that the order in the universe is continually decreasing and the disorder continually increasing. Thinkers with theological axes to grind have embraced this doctrine with enthusiasm, some because the prospect of the ' heavens waxing old as doth a garment ' seems to them to justify an appeal to neoplatonic other-worldly mysticism, others because the apparent original winding-up of the universe seems to restore a Creator to the necessities of thought. The ever-present possibilities of cyclical trends, however, or a continuous flow of energy through the universe, render their enthusiasm premature.

Side by side with the law of entropy, however, the chemists, geologists, biologists and sociologists had been laying the foundations of the law of evolution. For us, the inheritors of the work of the great popular exponents of the Victorian

period, the knowledge of the evolutionary development of the world is the permanent background of our thinking. We know that the original chaos of physical particles gradually gave place to the chemical elements as we see them to-day, including those with highly complex atomic structures ; we know how these slowly aggregated into molecules and these in turn into the very well ordered crystals and paracrystals. We recognise that in this milieu when the stage of complexity of protein molecules was reached life appeared, and from then on, through the simplest living cells to the most complicated and organised beings such as ourselves, the line runs clear. Nor can we exempt from this process the development of human societies, themselves in a social evolution attaining ever greater and greater complexity, passing through primitive tribalism, civilised forms of economic association such as feudalism and capitalism, and pointing forward to the world socialism of the future. The only guiding thread we have is the increase and development of organisation.

There is no reason for thinking that this organisation may not be measurable, just as entropy is. Embryologists have long needed a measure of differentiation during development of the individual. If we could have such a measure of increasing organisation during evolution, we might be able to assess the progress of human societies in concrete terms.

Here there is no opportunity to discuss how this seeming contradiction between physics and death on the one hand, psychology and life on the other, may be resolved. It is probable that the physicist's concept of order means only separatedness. Mixed-upness may be patterned as well as chaotic. It may be best to say that the world is passing from universal order to general disorder plus local, though ever higher, states of organisation. Of these we ourselves form part.

For man as a social being, however, the essential thing is that he stands at the growing point of a vast evolutionary process, the characteristics of which we can see pretty well. The march of living organisation, the progress of the world mind, will not stand still where it is to-day. For us at this middle point of time, the first duty is to appraise the social forces at work around us to see in what direction they are leading. Which of them make for higher social organisation, greater human unity, community and solidarity ; which of them seek to perpetuate lower stages of evolution, of the horde, of the tribe, of primitive man or even of animal life ? The answer is not in doubt ; fascist philosophers stand self-condemned. This is the point of view from which we should approach traditional systems of morality. Morality needs no supernatural sanctions ; its function is to state the means whereby human beings may live in harmony together, pooling their talents for the general good and collectively relieving their shortcomings. Since human beings are themselves, as units, the most highly organised living organisms known to us, they cannot be treated as if they were machines or as if they were animals, and any social philosophy which attempts to do so is ultimately doomed, even if, for a while, it should flourish like the green bay tree.

The social significance of science is indeed inescapable. It fundamentally rests on the checking and re-checking of observations of external nature made by countless human investigators. Their race, colour, religion or nationality is irrelevant to this function. Moreover, science alone, the ever-increasing precision and factual content of her language, has discovered how to attain substantially complete communicability between observers. This essentially social structure of science mirrors the oneness of humanity in other affairs, in artistic and religious experience (where communicability is far less) and in the production and exchange of commodities. Science is already a ' communitas,' a ' commune ' ; it will never be free to exert its full power in the benefaction of mankind until the social structure of mankind is also a ' commune.' Who has better recognised this than our chairman, H. G. Wells ? It was the basic assumption of all his ' utopias.'

But the idea is not utopian. The founders of ' scientific socialism ' called it so because they recognised the rising tide of organisation in the age-old evolutionary process, and they thought that that was a better foundation for a faith in coming human community than the deepest religious aspirations. But there is a further significance in the phrase. Freedom and authority is an ancient antinomy indeed ; social philosophers have ever wrestled with it and theologians have filled a multitude of books with discussions of it. But science is perhaps the only form of human activity in which the clue to its resolution has been found. The scientific view of the world forms a structure on the knowledge of which we have to act, but it is always open to anyone to upset as much of it as he possibly can, and no scientific training is any good unless it encourages the young scientist to question the fundamentals and to believe that facts may force him to demand their radical modification. Practical authority exists well enough, therefore, but the possibility of a Harvey or an Einstein has always to be taken into consideration, and freedom therefore exists too. It is true that recognition of the ideas of an unorthodox questioner may not come in his own lifetime, but that is a small matter where saecular trends are concerned.

If society, therefore, were to be so based on principles of reason and of ascertained social fact, if the exploitation of men were replaced by the administration of things, it would always be open for improvers to demand radical modification if they could show just cause. No ruling class in history has ever yet dared to face social criticism. Since its material interests are involved it reacts with police measures, until at length when criticism has become too overwhelming it resorts to civil war and itself passes into the museum of history. But in the classless state, towards which, as the profoundest analysis of social evolution shows us, we must look, the scientific administrators of government should be in the same position as the scientific investigators of nature. Here is a structure, examine it through and through, investigate and assemble your facts, make your proposals for improvement, if you can. To have attained this state of social rationality would be to have passed from the necessities of social conflict into the freedom of a realm where man could plan his own destiny.

At what is, in some sense, an international gathering, it is fitting that we should take some account of contributions made to human thought by civilisations other than our own. So far we have been considering the time-process ; what of other spatial regions of our world ? The very words ' social rationality ' call to mind a civilisation, far older than that of these western islands, which has contributed far more than is often supposed to philosophical and scientific thought. For present purposes we may roughly divide the types of civilisation (excluding abortive Aztec and African upsurges) into the Semitic-Occidental, to which we ourselves belong, the Indian, and the Chinese. It has been said that whenever modern man climbs to the top of some newly conquered mountain of intellectual achievement, he finds that the Greeks had shot an arrow there two thousand years before. Those of us who are acquainted with Chinese culture would add that when he looks again he finds a Chinese arrow too. I cannot claim to have anything of value to say on ancient Indian contributions, but I know that a progressive study of the course of Chinese philosophical thought filled me step by step with amazement and delight that in that ancient system, perhaps the only one comparable with the occidental system in richness and variety, so many ideas had found another expression, as if in a symphony on the same themes by another composer. Writing to Lorenzo de Medici in 1515 from China, Andreas Corsalis described the Chinese as ' di nostra qualità,' of the same stuff as ourselves. It was a compliment to us.

In the first place, China's greatest ethical philosopher, Kung-fu-tze (Confucius) was a moralist without supernaturalism. Long ages before anyone could have expected to see, as we do to-day, how ethics could arise as a social product within a natural evolutionary process when social man had arisen, he put human relationships first and supernatural religion a poor second. ' What are we to do,' his disciples were always asking him, ' about the gods and demons ? ' ' Respect them from a distance,' was his answer, ' but have as little to do with them as possible. First study how you may live with your fellow-men in peace, justice and love, then, when you have discovered that, you may ask me again concerning the gods and demons.' When irresponsible ascetics taunted him with his mundane interests he said ' I cannot live with animals. If I am not to live with my fellow-men with whom am I to live ? If society were as it ought to be, I should not be wanting to change it.' When asked what he would do first for the people, he replied ' Feed and enrich them,' what next, he replied ' Educate them.' Confucian naturalist ethics, scientific in spirit long before science, first became known to Europe in the eighteenth century ; they produced a deep impression on the scholars of the time. In Chinese culture the romantic and the rational have always been successfully blended. Its fight to-day against an imperialistic and irrational mysticism is identical with ours.

The greatest disciple of Confucius, Mêng-tze (Mencius), was extremely important on account of his view that man's nature is fundamentally good. Unlike the west, where Augustine was orthodox and Pelagius heretical, in China Mencius was orthodox and Hsün-tze unorthodox. This belief too reached Europe in the eighteenth century, and we know that it profoundly influenced the thinkers of the Encyclopædia movement, who laid the theoretical foundations of the French Revolution and of all subsequent progressive naturalist thought.

Later Confucian thinking became petrified into something of a scholasticism, and it was against this that Taoism reacted. Taoism represented in some degree the desire of the human mind to return from the ordering of human society to the contemplation of nature. Lao-tze's diatribes against ' knowledge ' were directed rather against Confucian scholasticism ; for the early Taoists, like the mystical theologians of our own renaissance, believed in the efficacy of manual operative acts. Many historians of science find that alchemy had its origin in Taoist magic : the search for the pill of immortality. A similar but more theoretical tendency is seen in the clear statement of relativity by the philosopher Chuang-tze. Particularly interesting is the relation between the Taoist concept of *chêng ching* (serenity of mind) which bears a close resemblance to the Epicurean ἀταραξια (ataraxia). This peace of mind, which comes from an intellectual contemplation of the works of nature, and a resignation to, because an appreciation of, the manifold kaleidoscope of the atoms, is still to-day a factor in the scientific world-view. By denuding the unknown of its terrors, it paves the way for the investigation of the unknown, and eventually the control of the known.

Lastly, the statement has often been heard that Chinese culture has been essentially stagnant, that it contained, unlike Greek thought, no germ of the understanding of evolution. This statement is wrong. In the ' Great Appendix ' to the *I-Ching*, one of the Chinese classics, dating from the fifth century B.C., there is an extremely clear account of three phases of human social evolution. The first phase is described in detail as primitive barbarism ; the second (the period of the ' Lesser Tranquillity ' : *hsiao an*) is an era of private property, coercive government, social cataclysms and war. The third (the period of ' Great Togetherness ' : *ta tung*) is no more and no less than the communal ownership of the means of production. Unfortunately we are still at the second stage to-day. I do not know of any parallel account of social evolution in Greek philosophy. It is true that Aeschylus, Hippocrates, Epicurus and Moschion did envisage the origin of human society from primitive barbarism, but they had little to say of the future, and most of the Greeks were dominated by the idea of cyclical recurrence or even of degeneration from a golden age. As for the causes which prevented the appearance of systematically organised science in China, that is a subject demanding much research and probably not to be solved without a corresponding understanding of how Chinese differed from Occidental economic history.

Summing up this contribution, then, we have seen that although physical order is everywhere decreasing, biological and social organisation is everywhere increasing. The human social organisation into which we were born has yet far to go towards its ultimate triumphs. The whole enterprise of science is a manifestation of this social

organisation, itself the product of evolution and the guarantee of further evolution. Our business is to find out how we may best make ourselves efficacious instruments of the cosmic process as it manifests itself in evolving human society, not caring if we perish in this cause, a holy and living sacrifice, seeing how much we ourselves have benefited from the acts of all the martyrs and ancestors from the beginning of the world. And not only is this cloud of witnesses about us in the time-process, but also, as has been shown, there come from the other side of the world ancient men, men of another colour but our brothers and kinsmen, witnessing to the truth of human solidarity and the unity of the world mind.

Prof. J. A. Lauwerys
The Scientific Content of General Education

THIS paper does not attempt to say anything original, but is rather an attempt to sum up the views of a whole group of educationists who represent among their number all those people in this country, excepting one or two, who are concerned with the training of teachers in science for secondary schools. It thus represents something like a consensus of opinion among those who may claim to be specialists in the teaching of science.

The curriculum of our schools is a hotch-potch, most of which we have inherited from a pre-scientific age. Its structure and content can be justified only by appealing to theories which we know to be wrong—great changes are urgently needed. We must make sure that the material presented to adolescents is relevant to their own needs and to the conditions of twentieth-century industrial society. What is required is a curriculum planned round natural science and the social studies, instead of one centred on linguistic and literary pursuits. We should be showing our pupils how modern men have learned to control and to use the natural environment, and explaining to them how institutions have arisen and are maintained to serve human needs.

Merely 'giving more time to science' is not enough, for at present its teaching is wrongly directed and too narrowly conceived. What is needed is as follows :—

(*a*) The material must be chosen from a wider field, and treated in a modern manner.

(*b*) More attention must be given to the teaching of scientific method. Skills of hand and eye (e.g. adjustment of instruments, reading scales, etc.) must be taught to all, and so must skills of mind. Adolescents must be accustomed to the rigours of safeguarded thinking and given practice in inductive work ; and they have to be shown that the intellectual virtues associated with scientific activity earn rewards far outside the present boundaries of science.

(*c*) The scientific attitude must be fostered and developed, its meaning made explicit : e.g. curiosity in the way things work, interest in the experimental approach, learning to distinguish between empirical and verbal questions, etc.

Aims as wide-reaching as those envisaged here would have been too ambitious fifty years ago, when talk, textbook, and blackboard were the teacher's chief tools. But we have learned to use workshop and laboratory ; visits to factories and museums are becoming quite usual ; radio, cinema and lantern are powerful aids. In addition, new techniques of teaching and new ways of organising material have been worked out. For instance, teachers are beginning to deal with teaching-units such as : 'How is pure water provided to cities ?' 'How can the yield of crops be increased ?' 'How have men learned to prepare and to use metals ?' A large number of such units can be, and have been, suggested. The criteria for selecting them are these :—

(*a*) They must be relevant to individual or to social needs.

(*b*) They must be such as to arouse pupil activity and participation.

(*c*) They must lend themselves to the teaching of scientific method and to the inculcation of scientific attitudes.

It might be added that, in planning these units, the study of the history of science and technology is enormously valuable. Lastly, the approach envisaged resembles in many ways the 'teaching of science in democratic societies' explored by the General Education Movement in the U.S.A.

Clearly, thus handled, science teaching ceases to be a technical and specialised affair. It helps to explain social organisation, it serves to get people used to thinking of knowledge in terms of human welfare—in a word, it becomes humane while remaining scientific. It will not achieve a swift revolution, but it may facilitate social transformation. We hope that citizens formed by such a regimen would be better able to deal with their own problems, and better equipped to deal with the chief task which faces modern society, namely : using to the full the resources of modern technology for the advancement of human welfare.

Mrs. S. Neville-Rolfe, O.B.E.
Biology in Human Relations

IT is claimed that social biology should occupy a prominent place in the content of the world mind. Firstly, social biology should be developed and opportunities accorded for its responsible application to current affairs. Secondly, a wider understanding and development of the emotional nature and needs of man is an urgent necessity. Thirdly, the emotional and intellectual force of youth should be admitted to effective participation in the war and post-war endeavour.

Victory of arms will not remove the causes of war. These lie in the lack of ability, character and emotional development of man himself. If the forces he has created are to be readjusted and canalised to human service and welfare, it is urgent to fit man for the task. The recognition that this is possible and a concentration of effort in an endeavour to understand and improve the quality of man, both of to-day and to-morrow, intellectually, emotionally and physically, would give a rebirth to hope.

The attempt of the Economic Conference to reduce financial tensions by a planned money policy (in 1927) failed owing to the recognition that man had not attained a standard of integrity and trustworthiness requisite to success. Countless instances exist of man's inadequacy being the barrier to progress.

Since the beginning of the century the ' boys in the back rooms ' of the universities, the experimental farms, the consulting rooms and the hospitals, have added much factual knowledge to our store, but its application to man has been checked by its seeming conflict with traditional values and by the barriers of prejudice and unreasoning fears inherent in man himself. Biology is being applied to his material advantage in agriculture, in medicine, and in food production, but consciously, hardly at all to man himself. Psychology has been discovering why man behaves as he does and disclosing the extent to which unrecognised and repressed emotions result in individual and group action entirely contrary to the dictates of intelligence. Physiology is explaining something of the interdependence of mind and body and the results of glandular disharmony on character. Anthropology and sociology demonstrate the dependence of the individual on the group and of the interaction between man and his environment.

What we now need is a concerted endeavour to collate, interpret and apply these various discoveries.

It is submitted that social biology rests on the factual contributions made by all sciences bearing on the development of man. Its task is to correlate and devise methods for their application, related to ethical principles, suited to the general pattern of each social structure. Suggestions made by other contributors have mainly been for the better organisation of scientists themselves : this is a request for a link between the scientist, the educationist and the public. An immediate practical step would be the establishment of an Institute of Social Biology, from which large-scale researches could be directed ; which would attract the best brains by furnishing well paid and socially valued research appointments. It would be a teaching and training centre, competent to advise Government and guide popular teaching. A wide range of war and post-war problems await attention—to select but few : migration and evacuation in relation to the family, nutrition and maternal mortality, population distribution, miscegenation, family allowances, optimum marriage age ; fertility, care and status of the unfit. The problems are legion.

After two generations of education in this country, the omission of social biology in school curricula has deprived science of an understanding public. Facts are discovered and published, but make little impression on individual practice, social behaviour, or administration, as they relate to nothing familiar and to no emotionally accepted values. Knowledge of nutrition, heredity and health is available, yet bad feeding, unprotected defectives and irresponsible sex behaviour prevail.

Measures are urged forthwith to relate social biology to ethical values, and to apply present knowledge to current problems. This is admittedly incomplete, but each additional fact, each extension of our intellectual range and of our capacity to appreciate beauty in form, sound, colour and sense, each new harmony between intuition and science that illuminates truth, clarifies our spiritual vision. Social biology drawing its facts from science may be pictured using them as pieces of a jigsaw puzzle from which each generation must compose the ever deepening and satisfying key-picture of what man is and can be.

Every educational system has concentrated on the training of intelligence, none has yet taken cognisance of the paramount influence of the emotional condition of man on his behaviour, or attempted to apply even our present knowledge of psychology. We are a world of emotional children with adult minds—babies playing ball with bombs. A true democracy can only be created by the emotionally and intellectually developed, inspired with a positive purpose in life.

Emotion and intelligence, united in a common objective, obtain astounding results in thought, in action and in conduct, as exemplified by the ideal of the League of Nations, the Battle of Britain, the brotherhood of the bombed and homeless. Unfortunately, even the groundwork of emotional understanding does not yet form a necessary part of the training of our leaders. Though some training in psychology is given to teachers, little emphasis is placed on the emotional aspect. Normal psychology and emotional development has as yet no definite place in the training of the medical and allied services or in that of the judiciary. Yet, how can a medical practitioner understand the whole personality of his ordinary patient when the only psychology he has studied is that of the abnormal ? How can the midwife and the Health Visitor handle problems of family adjustment and emotional stress with no understanding of this side of her own or her patients' nature ? How can the magistrate on the bench judge wisely, actions arising from subconscious repressions when these, to him, appear irresponsible excuses ?

That the younger generation welcome information and guidance on matters of social biology is evidenced by over 100,000 of the 16–25 age group who have attended *ad hoc* courses of lectures presenting a biological outline of how minds and bodies function, and encourage discussion on the related personal and social questions. These have been provided by progressive local authorities through the British Social Hygiene Council. Since 1932 the Educational Advisory Board has worked to promote the introduction of biology related to man into the educational system, and has made steady if slow progress, now gaining momentum through war conditions.

The emotionally immature, belonging to a previous generation, with a background of traditional dogma as religion, of *laissez-faire* as social economics, of philanthropic charity as good citizenship, and an idea of the ' equality of man ' which ignores biological evidence, are not qualified to govern. They fear youth and from a mistaken sense of duty they continue to bear burdens beyond their years, and are barring advance. Hence the time-lag in knowledge between the laboratory and the public is greatest in social biology.

To bring youth into world affairs, they must learn how to participate in the solution of daily problems. In every firm and works, on committees of management, the Whitley Councils, staff and workers' conferences—let young men and women be included to an adequate extent

(of a third or a half) in each group represented and secure an equal proportion in each local government committee, social organisation and voluntary body. Once the young see some hope of taking an effective share in the national effort, the service will not be lacking. The claim of youth to the knowledge that could equip them for life, the demand for opportunity to enable them to grapple with those problems beyond the grasp of the old in mind must be met soon, if the younger generation are to contribute effectively to the war and the post-war endeavour.

Recent inquiries confirm that only a small minority of young people are connected with any organised religion, yet the majority are seeking a positive philosophy of life, are disillusioned by the conflicting values, both ethical and social, to which lip service only is given. The war effort in principle claims and receives their support, but their enthusiasm is damped by obvious and, to them, preventable wastage of potential effort; but to them the war itself is evidence of man's failure. For twenty years the schools have taught the futility of arms as a means of deciding ethical values. It is recognised, of course, that to maintain our liberty to pursue our own values, victory in this struggle is essential, but it will not solve the economic, social and biological problems that made it possible.

The present 'Youth Movement' was inspired from Germany; though misdirected in aim, its methods were effective in giving the Nazi leaders what they sought, because emotional and intellectual effort was united; leadership was entrusted to youth; its driving force was positive.

The Scout and Guide movement, British in origin, also owed its success to its positive ideal and the leadership of youth.

The present Youth Movement has not included the biological essentials. The control of the movement is with few exceptions in the hands of ancient members of education committees, and of voluntary organisations established to meet Victorian ideas and conditions. It is unrelated to reality and therefore unrelated to youth. In some places, Youth Squads lend a hand in local war jobs; much needed clubs are started; but even mixed clubs are often considered as a dangerous development, and a few Education Committees hold that claims of youth 'could be considered after the war.'

The young to-day have a deep sense of spiritual values, but their positive philosophy must embody all truth as at present perceived. They are politically minded and see in personal freedom and impartial justice man's most precious possessions, but of the present incomplete interpretation of the ideal of democracy, of Fascism, Nazism or Bolshevism, indeed of all existing systems, they tend to say 'A plague on all your houses, we want something better!' Let them have the opportunity to create it.

Dr. J. S. Huxley, F.R.S.
The Scientific View of Education as a Social Function

In addition to our considering the scientific content of education, general or special, education must be surveyed and analysed scientifically, as a function of social life, just as respiration or digestion are surveyed and analysed as functions of the animal organism. Such a scientific survey of education and of the degree to which it is falling short of performing its social function adequately is one prerequisite for future world order.

Education has various social sub-functions—the general reproductive, in handing on existing tradition, language, elementary skills, etc.; the evolutionary, in modifying these traditions and skills; the normative, in setting standards of behaviour; the specialised, in training limited minorities, whether professional or governing élites.

Mr. Wells has pointed out one feature of education in the past—that it was confined to a small minority. We might add that its normative influence was exerted in favour of traditional orthodoxies of belief and behaviour, and that its conscious evolutionary function was almost or wholly nil.

The chief changes in the immediate past have been: (1) an increased emphasis on evolutionary or change-promoting functions, together with a decreased concern with the past, and an increased concern with the realisation of ideal but scientifically determined standards in the future; (2) an incipient concern in the normative sphere with the encouragement of the scientific attitude and the habit of thinking for oneself, as against implicit acceptance of traditional myths and orthodox morals; (3) the extension of more and better education to more of the people, but with the retention, in this country, of a dualistic class-system of education; (4) the development of a deliberately secular state educational system side by side with a denominational system.

At the present moment, those concerned with the social function of education are envisaging certain further changes as desirable: (1) the unification of the general educational system, both as regards its class aspect and its ideological (religious-secularist) aspect; (2) the tapping and training of the large reservoirs of unutilised brain power in the less wealthy sections of the community, both by an extension of general education and by increased facilities for specialised secondary and university education for a selected minority; (3) the provision of facilities for training the new potential élites, of the skilled mechanic and airman type, which the change in our class-structure is throwing up; (4) the need for enlisting education to help in providing a high degree of social stimulation and social self-consciousness, as the basis of a modern democratic but well-integrated society; (5) the need for uniting national educational systems with a common basis for world education.

These last two needs have arisen more or less simultaneously, and it is clearly easy for them to develop in antagonism. One of the jobs of the scientist is to help in seeing that they shall develop co-operatively, and that a strong local cultural self-determination and self-awareness shall co-exist with increased facilities for world self-awareness and for rapidity of exchange of ideas on a world scale.

This can be promoted in various ways: (1) by better scientific education, and the introduction of quantitative ideas wherever possible; (2) by

the encouragement of an international auxiliary language and the mechanical aids to the interchange of ideas mentioned by Mr. Wells ; (3) by the abandonment of the pretended universalism of the classical type of upper class education in favour of a relativist system, i.e. one related to the social needs of the particular society at the particular time, but given a universal basis by being further related to the common but evolving ideas and standards derived from a scientific humanism ; (4) by the deliberate fostering of cultural activities (art, drama, architecture, etc.) by the State, which would be best accomplished by a combination of some of the W.P.A. methods adopted in the United States with certain methods of mass cultural education and specialised cultural training developed in the U.S.S.R.

One danger we must beware of is the common phenomenon of threatened interests to resist the reduction or extinction of their influence with the utmost vigour. The most obvious case of this at the present moment is the attempt of the churches to extend their influence in general education, in the form of disguised tests for teachers, and in obtaining more of a foothold for orthodox Christianity in secular education.

This brings me to a general point, namely the extreme importance of avoiding a cleavage between education and the outside world ; e.g. it is hopeless to expect aesthetic values instilled at school to have much influence save on an exceptional minority so long as the world outside school is dominated by ugliness and the crudest commercial motives. That is why adult education and the general culture of society are important to the educationist in the narrow sense. But if the outside world must be related to the educational system as well as vice versa, it is equally important to avoid introducing into the educational system any features which are wholly out of touch with the standards and ideas of society in general. It appears to be a fact that the majority, probably the considerable majority, of our population are indifferent to orthodox Christianity in any of its forms. That being so, the introduction of compulsory religious worship or teaching into the schools along the lines demanded by the churches will not only defeat its own ends, since the average child immediately detects unreality, but will damage the general educational system in the process, since unreality in one school subject tends to infect the child's ideas about other subjects. There is also a secondary point, namely the sectarian cleavage between the various Christian denominations. The proposed invasion of our school system by Christian orthodoxy will thus represent a body of educational influence to be shared out like so much booty between the competing sects. This again will hinder the attainment of a properly unified educational system.

So far, I have been considering the social function of education from the angle of society as a whole ; it can, however, be considered also from the opposite end, from the angle of the individual citizens whom the educational system is training and developing. In this sphere science has made a major contribution, in the shape of the recent discoveries about so-called 'deep' psychology, notably those concerning the unconscious mind and the effects of repression. Man is the only organism habitually subjected to mental conflict ; and repression is the adaptive device for securing that conflict in the early years of life, when reason and experience are lacking to deal with it, shall not have disastrous effects.

However, the persistence of the infantile type of repression into adult life has several disadvantages—notably first the immobilising of a considerable amount of so-called mental energy, deadlocked between the repressing and repressed impulses, and secondly the distortion of the repressing forces, as in the typical primitive superego, so as to issue in various forms of unconstructive and intolerant prohibitions or even destructive sadism or violence, or in the sterile self-violation of excessive Puritanism or asceticism.

Thus in one sense the most important single task of education is not an intellectual but a moral and emotional one—the modification of rigorous all-or-none repression, and the substitution for it wherever possible of conscious suppression where required, in the light of tolerance and reason.

Once again, this problem can only be adequately attacked from both sides at once. If social conditions are such as to generate frustration and fear, or their opposite over-compensations, intolerant arrogance and brutality, no improvement in education will be of much avail. Hence the importance of all the measures already discussed at this Conference, aimed at increasing stability, security and freedom from the threats of ill health, poverty and war.

On the educational side, proper education of parents is one prime essential, to ensure that they shall not encourage and intensify the normal infantile repressions instead of the reverse. In school, it has been found that, for the young child, the encouragement of free self-expression through whatever medium turns out to be suitable to the individual case, whether painting, story-telling and writing, or constructive games, is of great help in the majority of cases. A second psychological crisis comes in adolescence. There is for one thing a general problem : the adolescent tends to suffer from what is known as an inferiority complex, which can only be purged away by providing him or her with suitable outlets for self-expression and above all by making him feel useful. On this latter point, the organisation of youth service corps and youth training schemes will be very valuable.

There is also a special point. Many of the most socially desirable types, potentially capable of intellectual, social or political leadership, are more or less sterilised, psychologically speaking, in adolescence because of undue sensitiveness, which accentuates the normal adolescent complex. A rich supply of these types is urgently needed to offset the influence of those who by virtue of undesirable qualities like insensitiveness, blatancy, and pushing, arrive much more automatically in positions of influence. Some experiments on this problem of giving balance and self-confidence to the gifted but sensitive adolescent have already been carried out, such as the County Badge training scheme ; and from these pioneer attempts it is at least already clear that bodily as well as intellectual and moral self-confidence is essential.

But a great deal of research and experiment is still needed if education is to be successful in its important function of finding, training, and equipping an élite worthy of the name.

In conclusion, I would emphasise that none of these problems can be satisfactorily solved if we continue to rely on orthodoxy and tradition, with our faces turned towards the past. Only the scientific method, of adequate survey and proper delimitation of goals, together with continuous research and experiment, will avail.

Count Zamoyski
Immediate Problems in the Rôle of the Scientist at the Present Time

I WISH to examine in a few words the rôle of the scientist to-day. This is a subject that I have been studying in this country many years before the war, and you may well imagine how difficult it must have been for me to find any response in the educational sphere for the political and social problems which confronted the scientist. The scientist feels very keenly his helplessness against the forces which were obstructing the penetration of science into the spheres of social life which we have been examining during this Conference. I cannot explain in detail the nature of these obstacles, but you know very well the part played by specialists, the animosity between the different departments, often of the same university, and the fact that humanists and scientists draw very far apart, and that their co-operation becomes very difficult. There are also religious and political feuds which obstructed, and to a certain extent disgusted, scientists from taking any active part in social and political life. In these conditions the work of popularising science was of extreme importance. Science was hidden from the layman to a very great extent, and as we have the privilege of having in our midst one of the greatest popularisers of science that has ever been, let us hope that those conditions which enabled the exploitation of the vast arsenal of modern science by a public hostile and ignorant of its vast achievements will never occur again.

In this respect, however, I wish to say a few words about the problem of popularising science. The populariser of science has often fallen into the pitfall of creating new barriers by representing the intellectual revolution which was going on in the laboratories and universities all over the world in a too embittered and radical fashion in the respect that it has unnecessarily aroused the animosity of the more conservative elements. It is of the greatest importance to make progress through the older channels wherever possible.

As far as the antagonism between the humanists and the scientists is concerned, I wish to suggest that it is the rôle of the scientist to acquire the wider scope of the humanist and bridge this gap which the humanist would never be able to do simply because he is incurably ignorant of the achievements of science. It is for you to give the lead in this vast fusion. Without this vast fusion and intellectual revolution, schemes of planning will only be monstrous new organs, and they will involve the organised tyranny of officialdom which we all dislike. If scientists are to make this plan a living machine we must all take an active part in this reconstruction, and appeal not only to science and to intellect, but to the emotions to which Mrs. Neville Rolfe appealed very genuinely.

I have a direct suggestion to make, and that is to ask you all to co-operate in introducing English as the universal scientific language all over the world, and particularly in central Europe, where the number of comparatively small nations cannot and should not afford the luxury and folly of intellectual autarchy. This presents a very practical possibility of co-operation in Europe among the Governments here represented, with some of whom I have discussed the problem, and by whom the suggestion has been most sympathetically received.

Prof. M. Skalińska, of the Polish Research Centre, a member of the National Board of Health, contributed to the discussion from the standpoint of biology and eugenics.

The Chairman

I HAVE a communication from Professor Photiades of Athens, who is a representative of the Greek Government here. He suggests that the communications of the men of science who have participated in this Congress should be organised and strengthened so that they may go on as a continuing process. The British Association and its kindred associations with other countries can, I think, give just that organising effort for which Professor Photiades is asking. It gives already an opening for a very free and spirited transmission of scientific ideas throughout the world. Each association links up with another association in each country, though some are in a state of suppression.

Dr. J. Skladal
Proposal for an International Academy

THE policy of the post-war world will take on a quite different shape to that which used to be regarded as normal after the last war. The future path of State policy will lead away from the anarchy of economic and political nationalism and its consequences towards a constructive organised and planned co-operation of all States for fulfilling the fundamental, material, technical and moral human needs based upon the rationalistic and humanitarian attitude of science. This basic practical orientation of the post-war policy of States and nations will need to be organised in a centrally co-ordinated institution of sciences, arts and practical international co-operation. The last commission of intellectual co-operation of the League of Nations was not sufficient to accomplish this purpose. It is necessary to build up a solid and largely international institution working upon a steady and firm co-operation of research workers, thinkers and artists of all the world.

Thus, we are facing the necessity of an international or at least a European academy, which will become a real laboratory of best brains for fighting against war, against poverty in plenty, for the human dignity against all forms of Fascism, for European consciousness and world citizenship against economic and political anarchy.

The aims of the academy may be divided as follows :—

(1) *Internal*

(*a*) Centre of co-ordination of scientific research, scientific education and scientific co-operation.

(*b*) Centre of registration, classification and publicity for scientific and technical discoveries.

(*c*) Centre of publicity and popularisation of scientific knowledge.

(*d*) Centre of publicity for the fundamental achievements of human thought and art.

(*e*) Centre of scientific study and publicity for causes and conditions of social crises and international conflicts.

(*f*) Centre of scientific research and publicity for the fundamental biological and social needs and standards of human beings.

(*g*) A high school for teaching the unity of mankind and the problems of closer international co-operation.

(2) *External*

(*a*) Brain trust of the international (European) political executive and instrument of international consciousness.

(*b*) Bridge between western and eastern civilisations.

(*c*) Guard of liberty of thought and individual and national rights.

(*d*) Technical adviser of the international (European) political executive.

(*e*) Guard of the objective and humanistic spirit of the entire school education.

To accomplish these aims, the academy should be based upon the following principles :

(1) A charter of humanistic belief (positive humanism).

(2) A formally granted firm and mutual contact with the international (European) political executive.

(3) Financial and political independence.

(4) Widest international choice of qualified workers.

(5) The widest publicity of the work of the academy and of all its results.

(6) The decentralisation of laboratory research in the respective countries.

(7) Centralisation and elastic administration within the academy.

(8) Firm contact with all the institutions and men working on the same basis outside the academy.

(9) An autonomy of choice of its members and all the personnel. The Nobel Prize winners living in the non-Fascist countries to form an assembly which will elect the first nucleus of the council of the academy.

(10) A gradual working programme adapted according to the actual needs of society.

ADDITIONAL COMMUNICATIONS

Arrangements were made for messages from scientific representatives overseas, which it was intended to communicate to the Conference. That from Field-Marshal Smuts, given below, was duly received by radiophone, thanks to the generous collaboration of the B.B.C., was recorded, and was heard by the audience. Those from Prof. Einstein and Dr. Conant were recorded in America, but the records unfortunately were not received in time for use at the Conference. The same applies to the written communications by other American scientists, and to that by Soviet scientists, which follow.

Field-Marshal the Rt. Hon. J. C. Smuts, P.C., F.R.S.

(Past-President of the British Association)

MOST personally, and as one of the past-Presidents, I rejoice in the news that the British Association will hold a conference this year, and thus preserve the continuity of its work as the parent association of science in the world.

That light—the light of science—should never be quenched whatever happens. Science is at least the greatest torch which the spirit of man has kindled in the modern world, and nothing—not even in this dark hour of our civilisation—should be allowed to interrupt its kindly light. And it is fitting that this conference should be held in Britain, the mother, and now the citadel, of modern democracy, as America is its arsenal. This is her honour and glory ; just as to-day hers is the agony.

Science and democracy go together, stand or fall together. Both have their roots in the worth of the human soul. Democracy represents the freedom, the dignity and the sovereignty of the personality in our human society ; while science is the expression of our loyalty to facts—accurate and tested facts as distinct from fancies, prejudices, and propaganda.

Science thus stands for our faith in reason and truth, the truth which alone will make man free. And to-day the hearts of all men over the wide world turn to this island, which fate has selected for this high rôle of freedom's champion, and for measureless sacrifices. Our thoughts, our prayers are with her in this her greatest hour.

Assault to-day is not merely against political liberty and the institutions of free self-government : it goes much deeper. The whole ethical basis of our western way of life is challenged. In the Nazi system there is no place for law or the equality of all before the law, nor for the honourable observance of the pledged word, nor for the sanctities of private life, nor for decent human behaviour as between man and man. In fundamental respects, the ' new order ' is a return to the old slavery, with the Gestapo added. And in particular, the proud position of science is challenged. It is abused and degraded until it becomes no better than propaganda for myths and beliefs long since discarded. Its universal status, which is its proudest claim, is denied, and it is reduced to a mere national, racial, or provincial standing. And so one hears of German science, German mathematics or physics, while scientists become subservient agents of State propaganda. Indeed, science becomes as much a tool of the State as the human personality itself.

Free critical research and testing by universal standards are frowned upon. The disinterested, friendly search for truth which forms the glory of the human race, withers away, and we go back to the Dark Ages. If such is the threat which the new order holds out over science, it is hard to think that this menace should come from countries such as Germany and Italy, which for centuries played a great part in human advance, and not least in social progress. But let us hope that this upheaval will be only temporary. It should be for us to make it so, and to cause this lapse to pass like a bad dream of the night through which we are fighting our way.

When the day comes with our victory, science will not be merely reinstated to her honoured status and substance : a new era will open before her. Already this Association has made a beginning by making the co-ordination of the social relations and consequences of science one of its major divisions. The co-operation of science with other social agencies to this end may yet become its greatest service for human progress, and so victory will not only preserve what science has achieved in the past, but will open up a glorious vista of advance for the future.

Prof. A. Einstein

The Common Language of Science [1]

THE first step towards language was to convey impressions of events by symbols, acoustically or otherwise. Most likely all sociable animals have arrived at this primitive kind of communication, at least to a certain degree. A higher development is reached when further symbols are introduced and understood which establish conveniently these other symbols, and convey relations to events indicated by them. At this stage it is already possible to communicate somewhat complex lines of events ; a language has come into existence. If language is to lead to understanding at all there must be rules fixed among individuals, who are connected through the language, about the symbols on one hand and the events and their relations on the other hand. To comprehend these rules is a problem which individuals associated through the same language solve mainly by sheer intuition in childhood. When one becomes conscious of these rules, a grammar, so-called, is established. In an early stage every single word of the language may correspond to impressions. At a later stage this direct connection is lost in so far as at least some words convey impressions only in connection with other words ; for instance, such words as ' is ' or ' thing.' Then words are no longer attributed to impressions, but combinations of words to groups of impressions. When language becomes in this way partially independent of the background of impressions one reaches more internal coherence and independence. Only at this higher stage of development language, which uses plenty of abstract concepts, becomes an instrument of reasoning in the true sense of the word. But it is also this development that turns language into a dangerous source of error and deception. Everything depends on the degree to which words and their combinations correspond to the world of impressions.

What is it that brings about such intimate connection between language and thought ? Is it impossible to think without using language, namely in concept, and concept combinations, for which words need not necessarily come to mind ? Has not every one of us occasionally struggled for words after he had conceived a clear idea of relations of things ? We might be inclined to attribute to the act of thinking complete independence from language if the individual formed or were able to form his conception without communication with other people by language. Yet, most likely, the shape of thought of an individual growing under such conditions would be very poor. We are, therefore, bound to conclude that the mental development of the individual, and especially the way of forming and combining concepts, depends to a high degree on language. This makes us realise to what extent the same language means the same mentality. In this sense thinking and language are linked together.

What distinguishes the language of science from language in the ordinary sense of the word ? How is it that the language of science is, on the whole, a language common to everybody ? What science tries for is utmost preciseness and clarity of concepts as regards their mutual relation and their correspondence to sensory data.

As an illustration let us take the language of Euclidean geometry and algebra. There is a small number of independently introduced concepts and symbols—such as the integral number, the straight line, the point—as well as fundamental relations to the combinations of these concepts. This is the basis for the construction or definition of all ordered statements and other concepts. The connection between concepts and statements on the one hand and sensory data on the other hand is established through acts of counting and measuring, the performance of which is sufficiently well determined. The supernational character of scientific concepts and scientific language is due to the fact that they have been set up by the best brains of all countries and all times. In solitude, and yet in co-operative effort as regards the final effect, they created the spiritual tools for the technical revolution which has transformed the life of mankind in the last century. Their system of concepts served as a guide in the bewildering chaos of perceptions so that we learned to grasp general truth from particular observation.

What hopes and fears does the scientific method imply for mankind ? I do not think that is the right way to put the question. Whatever this tool may produce in the hands of men depends entirely upon the nature of the aims alive in mankind. Once these aims exist, the scientific method furnishes means to realise them. But it cannot furnish these aims itself. The scientific method itself would not have led to anything, it would not even have been born at all, without a passionate striving for clear understanding. Perfection of means and confusion of aims seem, in my opinion, to characterise our age. If we desire passionately the safety, the welfare, and the free development of all men, we should not lack

[1] Radio reception was difficult in parts, and this version has been compiled by collating the speech as spoken in English and the text in German.

the means to approach such a state. Even if only a small part of mankind strives for such an aim, their superiority will prove itself in the long run.

Dr. James Conant [1]

As I recall my visit with you of last winter, and at the same time visualise a meeting of scientists on the western line of battle, the temptation is for me to speak solely with my heart, but that temptation I must put aside, for I assume you have asked me to address you because I am chairman of the National Defence Research Committee, an arm of the United States Government. In that capacity, it is perhaps fitting that I should have something to say about the mobilisation of science in the United States, and the co-operation of British and American scientists for the war effort. On the other hand, many things that I have said as a private citizen of the United States concerning the foreign policy of my country would be entirely inappropriate in this address. To some of you my views are known ; I can only say that I hold them with greater conviction every day. Many of my fellow-scientists and academic colleagues on this side of the water are of the same opinion, others have disagreed. But on one point all American scientists agree—they unite in saluting the bravery of the British nation, they applaud unanimously your gallant stand ; moreover, as scientists they are proud of the vital rôle their fellow-workers of Great Britain are playing in the struggle now in progress. They realise, though often only dimly, that history will surely record this heroic struggle as a defence against almost overwhelming odds not only of Great Britain but of individual liberty throughout the world.

In June 1940, the first realisation of a world crisis aroused America. Amidst violent debates on foreign policy a vast programme of rapid rearmament was initiated. As to the necessity for producing at top-speed the great quantities of instruments of war, there could be but one opinion. Under these circumstances it was essential to mobilise the scientific talent of our country with all haste. The National Defence Research Committee, with Dr. Vannevar Bush as chairman, was then created by Presidential order. Its task was not advisory, for the scientific advisory bodies of the Government had long been in existence. The National Academy of Science, that parallel of your Royal Society, has, by Congressional Charter, the duty of advising the Federal Government on scientific matters. The National Research Council, a creation of the Academy, has functioned effectively to that end for many years. It still continues to play an active rôle, particularly in the field of medical research. What was needed was not another advisory body, but an executive agency, capable of bringing available scientific talent as soon as possible in touch with the army and the navy—an executive agency to speed up the scientific research on instrumentalities of war by drawing on existing laboratory facilities of the whole country.

This was the function the National Defence Research Committee was created to fulfil.

[1] Slightly abridged from the spoken communication transcribed from a telediphone recording.

The new committee was composed of six civilians together with a representative of the Secretary of War and a representative of the Secretary of the Navy. Rather than establish any large organisation of its own, the National Defence Research Committee decided to use its available appropriations through contracts with universities and industrial firms which would carry on specific research and development on secret matters pertaining to modern warfare. Through various sub-committees or divisions, each headed by a committee member, the work was divided. Liaison officers from the army and the navy were attached to the various sub-committees. In this way the scientists brought into the new work were kept in active touch with members of the armed forces.

During the past year over ten millions of dollars have been spent through 270 contracts placed at 47 different universities and technical colleges, and 153 contracts placed with 39 industrial firms. Needless to say, great precautions have been necessary to ensure the secrecy of the work. No man has been brought into the organisation either as a member of a sub-committee or as a contractor without the approval of our army and our navy. Great care has been taken to ensure secrecy in the placing of contracts either with academic workers or industrial firms.

In both physics and chemistry the effort has been to distribute the problems as far as possible to different investigators throughout the country. In this way, during the initial year at least, normal functions of our universities were as far as possible undisturbed. In a few cases the nature of the work has made such an arrangement impossible. In one case in particular, the Radiation Laboratory at the Massachusetts Institute of Technology, it was essential that a large group of physicists should be assembled to work on a highly confidential and important subject with greatest possible speed. Therefore, more than 150 physicists from twenty-five different universities in all parts of the country have been brought together to work towards a common goal. We estimate that approximately a thousand scientists ranging all the way from senior professors to young Ph.D.'s are now at work, in one way or another, in academic institutions under contracts with the National Defence Research Committee. Furthermore over 700 scientists of the same grades are at work in industrial firms in connection with the contracts which have been placed there. As in your own country, we have found that the nature of the problems in this present war are such that physicists and certain types of engineers are in greater demand than chemists. Indeed it would appear, from a survey recently made, that probably 75 per cent. of the more distinguished research physicists of the country and other American men of science who are available are now at work on war problems. I hazard the opinion that it will be only a few months before the remaining 25 per cent. are equally involved.

The success of the undertaking has been due in no small measure to the effectiveness of Dr. Vannevar Bush, both as a scientist and as an administrator. Dr. Bush was the chairman of the committee during the first year of its existence and

shouldered the responsibilities for the enormous task. Three months ago, by order of the President, he was made director of a newly created Office of Scientific Research and Development. In this capacity Dr. Bush was charged, not only with the many responsibilities which he had formerly carried, as chairman of the National Defence Research Committee, but with a further task of co-ordinating scientific research on medical problems affecting national defence—and most important of all he has the charge of co-ordinating, and, where desirable, supplementing, the scientific research activities carried on by the Departments of War and Navy and other agencies of the Federal Government. The National Defence Research Committee now becomes a part of the new Office of Scientific Research and Development and I, as the new chairman, am responsible to Dr. Bush.

Parallel to our committee is one newly formed on Medical Research, of which Professor Alfred N. Richards is chairman. Together these two committees will be the main instruments which the Office of Scientific Research and Development will use to carry out the task entrusted to it by order of the President of the United States. Such, in brief, is the organisation which has been created to bring about the rapid mobilisation of scientific talent in the United States to aid the armed forces of the Federal Government.

Those who are interested in problems of organisation and administration will note that the scheme is both flexible and temporary; it is clearly designed to last only during the period of national emergency. No new permanent organisations are created, no new Government laboratories are built or staffed, no large administrative offices are established. Rather, methods have been advised by which with all speed possible the available scientific talent and laboratory resources of the country could be used to supplement the already existing research establishments of our army and our navy.

One of the happiest results of the past year's labours has been the ever-increasing Anglo-American co-operation in scientific fields. This was at first made possible, on our side of the water, by the National Defence Research Committee; it is now a function of the new Office of Scientific Research and Development. The executive order which established this office, Dr. Bush at its head, provided that the director should initiate and support such scientific research as may be requested by the Government of any country whose defence the President deems vital to the defence of the United States under the terms of the Lease-Lend Act of March 11, 1941. After more than six months of work, our interchanges of information and of workers have yielded results of considerable importance—results particularly significant to us in the United States, who are so far removed from the actualities of battle. I believe that we, on our side of the Atlantic, have contributed something to your great effort, and I hope and pray that our contribution before many months are passed will be of the first order of importance. For I know I am speaking for my fellow-workers in the National Defence Research Committee, when I say that nothing would give us more satisfaction than to feel that through our work we had contributed directly to the effectiveness of your war effort. Our eagerness to help can hardly be over-estimated. May the future demonstrate that our capacities have been equal to our desires.

I cannot conclude without referring briefly to what must be to some extent in everyone's mind at this conference: the world we are going to live in after this war is over. It is not for me to outline a world order, or even to express views on Anglo-American policy, but no intelligent man who on the one hand loves peace and on the other places the highest value on individual liberty, can doubt that without some form of co-operation between our two countries no peace worth fighting for can be established. Similarly no intelligent man who consults his head as well as his heart can fail to note great obstacles standing in the way of effective co-operation and collaboration. It should be the duty of all trained thinkers, particularly scientists, on both sides of the water, to study these obstacles coolly and impartially, for only by knowing their nature may we hope to overcome them, only by dispassionate study may we hope to reduce these barriers. I say particularly scientists, for men of science realise more than many others the potentialities that lie hidden in the future. Men of science realise, as many cannot, the extent to which modern technology has diminished enormously the effective distances around this planet. They know, too, that the end of this revolution in transportation is not yet in sight. The world contracts before their eyes—to them, dreams of new adventures, new conquests of the material universe, wait for realisation only on the sustained labour of free men.

To-day the scientists of Great Britain and the United States are working almost as one group, with a purpose of improving instruments of war. Is it fantastic to hope that in the not too distant future the scientists of all free countries may be joined in effective action to improve, not instruments of war but those of peace? I like to see in the present scientific liaison that runs through the centre of London, Ottawa and Washington, a hopeful omen of a long period marked by the friendliest relations between the British Commonwealth of Nations and the United States. If this be so, our work foreshadows the time when professional talent in many diverse societies of free men will strive for effective co-operation to the end that we and our children may walk boldly along the paths of liberty and peace.

Mr. Watson Davis
World Order from Science

THE immediate world struggle in which we are all so concerned is a virulent phase of the age-old struggle between revealed 'knowledge' and the scientific or experimental method of living. Our first objective is to re-establish to large areas of the world the right to determine how they shall live their own lives, compatibly with the world good. Simultaneously there must be planning and accomplishment looking towards the practical establishment of a world order in which science, reason and the general welfare will reign supreme. This is no impossible task. This ideal has been approached in limited areas. We need a world approach and a conscious, planned participation,

not alone of scientists and philosophers of good will, but peoples and their freely chosen governments. A movement towards such a world order must be inaugurated, based on scientific practicalities. There must be popular ' education ' to this end, based on such broad visions as those of H. G. Wells. Education, in this sense, is not primarily of the school but of the daily life, through press, radio, books, pamphlets and the interplay of human minds. It is not enough to say that we shall start this work when Hitler falls, or when the peace is discussed. Now is the time. We should do to-day anything that we foresee needs to be done to-morrow.

The world never knows enough. But it does know enough to make this a much better world in which to live. We could banish hunger and malnutrition. We could banish fear and superstition. We could see to it that the material riches of the world are available to all who need them. We could see to it that our prevailing passion is not for money but for service to fellow human beings. With psychiatric insight, we could divert the insanities of military aggression into constructive channels, or, if they are incurable, curb them with the latent strength of the world. We need to bring practically the various skin colours, customs, religions, and sociologies of the world into accord, using the flux of science.

It is a gigantic task. In a certain sense, the future has always been impossible. The future arrives and disappears with every dawn. We must greet the dusks of to-day and the dawns of to-morrow with good will and firm resolution, with the best blueprints we can draw, and with strong minds and backs. If we work together we can do it. But we must get started, now and right.

Prof. Joseph Hudnut
Architecture and Science

MODERN architecture, whenever it is more than fantasy, is the visible expression of a way of life created by modern science. Whatever authority the new architecture may possess it will owe to its power, unique among the arts, to attain and make known the nature and intent of science—of that science which first transformed and then shattered our modern world, and, when the great storm is ended, will rebuild the world in a pattern even more conformable to its triumphant spirit.

Not truth for its own sake, but truth in its relation to humanity, is the theme of architecture. Unlike the scientist, whose field includes every aspect of the knowable world, the architect is concerned only with whatever reaction may take place between that world and man. Unlike the scientist, who apprehends all non-human things in general and abstract terms, the architect's habit of thought is directed continuously by considerations of social content and usefulness. The architect is aware, through feeling no less than through knowledge, of the human relevances of science ; and his art is sometimes adequate to seize upon these and, in his own language of constructed form, to express them. Science states these relationships, describes, and explains them ; but architecture makes them accessible to experience.

Most of the arts of our day are integral, not with our own culture, but with the cultures of the past. Their attitudes have not been related to the social consequences of science—still less to its philosophical implications. Taken as a whole, the arts are scarcely aware of the vast changes wrought by the application of science to industry, by mechanisations and new modes of energy, by the wider dimensions of experience ; nor are they aware of the present schism between our knowledge and our habit of belief. The art of architecture, because it is compelled, however reluctantly, to make use of industry, and because it must by the laws of its own nature conform to the new ways of life which these have evoked, belongs, alone among the arts, to our own time. Architecture alone offers herself freely to the pressures and resistances of a present society and receives through these the imprint of the science of which they are, in part at least, the consequence.

Modern architecture is not to be defined as the exploitation of modern technologies. Such a definition clearly mistakes the means for the end. Not invention, but the use made of invention, is the true measure of an architecture ; and the most modern of technologies can be made into the form-language of romance. Nor will technologies by themselves, untouched by imaginative insight, suffice to create an architecture ; they are bridges merely, over which a formative spirit may enter and control constructed forms. Neither an arid materialism nor the caprice of genius forms the substance of modern architecture, whose patterns, conditioned upon structure and use, are yet subject also to those intuitive reshapings by means of which the artist, since the beginnings of history, has arrived at expression. The modern architect, by means of processes as ancient as his craft, illumines the meanings of modern science and, at times, exhibits her consoling promises.

Prof. Frank B. Jewett
Natural Law and Obedience thereto

I SOMETIMES think we over-emphasise the word ' science ' as though it designated a special world, and as though the coterie who dwell therein were creatures apart from the general run of mankind. Science, as I see it, is nothing but tested knowledge (' organised knowledge ' we frequently say) and the scientist is distinguishable from his brother human beings merely in that he devotes his major effort to acquiring and testing knowledge or to putting new knowledge to practical use.

Whatever the meaning and value of science to the scientist, whose bump of curiosity is developed to the extent that he must ever be in search of new discoveries, its practical value to the world at large lies (to use a hackneyed expression) in placing man in tune with his environment. The properties of man's surroundings and the principles which they obey must be dealt with understandingly if we wish to achieve maximum results. Primitive man, being unaware of most of the natural laws underlying the phenomena around him, could avail himself only to a negligible extent of their assistance. Thus combustion, which can be a serious menace in the forest or the prairie, can be turned to extremely important uses when the requisite information is at hand. There is danger in lightning, but no end of benefits can be derived from electricity when handled understandingly. Likewise the multitude of laws of chemical combination are a mighty help when known and their implications obeyed.

I do not pretend that there is anything new and startling in asserting this basic fact. The principles of physical nature are well recognised as helps or hindrances, depending upon the skill with which we make our actions conform with them. They will not be thwarted, however; only by giving compliance can we marshal them to our aid. But though such an attitude is commonplace as regards the physical sciences, it is not so clearly understood, I believe, that we must be like-minded towards man himself. I place as a primary need of the future a clear recognition that a like criterion of right and wrong behaviour rules in the social and political domains. Mankind in the aggregate, I suggest, is ruled by laws or principles of behaviour as immutable as those which guide the performance of the molecules of air he breathes. Strife and calamity are the bitter fruit of ignorance; success and achievement the reward of knowledge.

To be sure, the laws of social behaviour have not proved as easy to discern as have those of the material world. Newton, single-handed, was able to envisage and enunciate clearly the law which guides the planets in their courses. Faraday and Maxwell drew a correspondingly clear picture of the domain of electrical phenomena. But the world has still to rear its social Newtons and its political Faradays and Maxwells. Indeed, the task is so complex (and seemingly becoming more and more complex with the daily growth of physical knowledge and our desire to take full advantage of it) that one wonders whether these social and political discoverers, when found, may not prove to be groups of able investigators who have banded together to secure the increased power of carefully focussed endeavour—not individual human beings. At any rate, the urgency of broader understanding grows; human destiny demands that we lose no time in rounding our knowledge out.

In closing, I quote a sentence from Sir William Bragg because it so well illuminates the thought behind my own words: 'We do not claim that scientists shall be entrusted with authority because they are scientists; we do claim that authority shall be exercised in the light of a knowledge which grows continuously, and with continual effect on politics, on industry and on thought itself.'

Prof. Ernest O. Lawrence

Science and Human Needs

DESPITE the overwhelming benefits of science to all humanity, one does hear occasional outbursts against progress. There are the familiar complaints that human morals and human relations, political and social, are not keeping pace with material progress, that science is a bane rather than a blessing. Some go so far as to say that unless there is a moratorium on scientific progress, civilisation will be wrecked. The kind of thinking that leads to such an absurd conclusion reminds me of a childhood argument that 'the moon is more important than the sun because the moon shines in the night-time when we need the light.' Those who deplore scientific progress in the same way completely ignore the vital rôle of science in human needs.

At the moment, the greatest human need is peace and justice over the world, and this means that science's greatest immediate task is to implement with ever more powerful and effective weapons the forces for good to fight the forces of evil. To this end scientists almost to a man in this country are bending their efforts. I know that I speak for hundreds of American men of science when I send to our British colleagues heartiest greetings and good wishes along with assurances that we are doing our bit in behalf of the preservation of our common ideals of freedom and justice.

Dr. Harlow Shapley

Concerning Blueprints for a World Structure

AIMLESSNESS, concealed behind rusty slogans, characterises so much of our current social policy that science and the activities of scientific men are largely turned from world problems to the immediate utilities. The goals are nearby and not inspiring. The sooner it is commonly realised that either a world state or chaos and recession lies ahead, the sooner we can shape a programme for scientists that appears constructive and is appropriately dignified. Until then we are merely skilled mechanics with our eyes on the time clock.

The world state need not be narrowly conceived nor specifically defined. The name can be sugar-coated, if unpalatable in its raw and real form, with phrases like 'Association of Free People,' 'The New World Order,' 'League of Nations.' However camouflaged the world state is not far ahead, unless the pessimists are right.

It is probably necessary, as a first step, to quit airing our historic erudition by sophisticated references to Carthage and Rome, to the French Revolution, to the unchanging human greed and the gullibility of men in crowds. The Reformation is not a useful analogue. The arts of communication have irreversibly changed the setting. San Francisco is adjacent to Moscow, and Honolulu soon will be a pleasant suburb of New York City. If civilisation persists, we cannot go back to strictly national cultures and countries. Too many thousands of ingenious people in too many countries now have intimate knowledge of radios, wing structures, photography, synthetic chemistry, and atomic transformations. The planet, in brief, is now too small for cultural or economic isolation to persist much longer. This simple and obvious situation should be commonly recognised.

Would it not be silly to struggle for another generation or so against the rise of world unity? It is not even necessary to wait the short time of two hundred years for the stabilised and rather highly homogeneous world state. It is difficult to imagine how there could be, fifty years from now, a world order resembling that of 1910 or 1930. Something deeply different is inevitable. Shall scientists go forward to meet it and help shape the future, or work madly on immediate necessities, as at present, with minimum emphasis on goals?

From an educational standpoint it seems highly important that we work towards a common recognition of the inevitability of a world state. And from the men of far-seeing wisdom should come some blueprints, if the world structure is not to be whimsical. It certainly is not now sufficient, whether as a structural preliminary or as nutrition of social morale, to get important individuals piously together for the repetition of the Ten Commandments. It is not sufficient to make grand pronouncements that there might be ethics and morality in business affairs after the present war.

It is only a temporary encouragement to recite and sign solemnly obvious axioms—axioms that are included in almost any ethical system. The eight points of the Churchill-Roosevelt agreement are implicit in the doctrines of all the great religions, and are good now, as they have been for hundreds of years. But we need more inspiring goals.

The blueprinting is, of course, not for scientists alone, and certainly it cannot be left to diplomats assisted by shortsighted economists. The draughtsmen must be advised by anthropologists, social psychologists, men who know the religions of people, as well as the more obvious geographers, agriculturists, and engineers. An aim must be the end of aimlessness. Although they must be tempered by expediency, the blueprints should recognise the present small size of the planet, the futility of presumption of racial superiorities, the futility of striving for restoration of a previous social order, the recognition that possibly some good points for the adjusted world order can be obtained from the social philosophies of the totalitarian states, and they should recognise especially that if we strive to model the future on the Anglo-American present we are just setting up another great world sorrow and are not going out to meet the coming world state in the frank and intelligent manner that should become the scientific man.

Prof. Harold C. Urey

WHEN this war is won, we shall face the difficult problem of reconstruction and reorganisation of a badly disorganised world. This is a problem even more difficult than waging war, because patience, forethought, tact, and appreciation of the position of others, are so much more difficult in practice than the rash partisanship of war.

All the experience of this century shows that in this reorganisation, a much closer co-operation of the democracies of the world, and particularly the English-speaking nations, will be necessary. The necessity in war is illustrated in two wars of this century and the economic disorganisation in the troubled times between them shows that in peace-time national activities are no longer independent.

The rapid growth of science and technology has very largely caused the successes and to some extent the failures of this century. The obliteration of distance, mountains, and oceans as defence barriers makes necessary quite different units for defence as in the present war. The new methods of mass production, which are the result of science on the one hand and the limited liability corporations on the other, have made a country so large and varied as the United States very dependent upon the outside world, while the effect of these things on small countries has been so great that complete independence for them is impossible. Much of the economic disorganisation of this century has been caused by the impact of these mass-production methods on the wholly unprepared social and economic traditions of the nineteenth century.

In this reorganisation which is now necessary, perhaps the scientific methods may be useful. Science has developed almost a perfect international outlook in its own field ; it develops conclusions based on most carefully collected data and by most carefully reasoned considerations ; it has almost an inhuman objectivity and carefully eliminates personalities from its conclusions ; its devotion to truth is of the purest. Incidentally, scientific discipline is perhaps most nearly the exact opposite of the Nazi philosophy that we find in any of our varied activities.

It is to be hoped that in building a new world, such ideals and disciplines as those of science will play an important part. Psychology teaches that patterns of behaviour practised by a person in one field of activity will not be applied by that person in other fields, and pronouncements of scientists on other fields than their own most certainly in many instances do not follow the cardinal characteristics of science mentioned here. All, including scientists, must learn to apply scientific methods to other problems than science. The history of science shows that order and progress have been achieved in each new field to which scientific methods have been applied. The complexities of men are so great that the application of scientific methods to human behaviour may be something like Christianity, which we strive for but never attain. Experience in the simpler fields of the exact and natural sciences leads one to believe that the attempt will be useful.

The forty odd years of this century have witnessed the greatest industrial and intellectual revolution of all time, due largely to the impact of science and technology in our times. They have also witnessed the most destructive wars and also most profound economic maladjustments probably related to the same causes. I am confident and, in fact, completely certain that in a generation or two men will learn to live successfully with the new abundance that this century has produced. In fact, when men in all walks of life learn that plenty is available for all in this modern world, and learn this so thoroughly that it is part of the background of their thoughts, these wars and uncertainties of life will disappear and the dreams of scientists of good for all will become reality.

Message from the Academy of Sciences of the U.S.S.R.

THE Academy of Sciences of the U.S.S.R. sends its warmest greetings to the conference of scientists called in London by the British Association for the Advancement of Science. In all countries men who have devoted themselves to scientific and research work are united by one conviction—that the aim of science is to bring about the well-being of humanity. This general conviction unites the scientists of various nations which fight together in this great struggle for a just cause. The Soviet scientists who are fighting for the happy future of mankind against our common enemy, shoulder to shoulder with their colleagues in the allied countries, will not spare any efforts to achieve final victory. This will be a victory of freedom, culture, science and civilisation over barbarity, tyranny and obscurantism, a victory of the bright future over the dark past.

(Signed) V. L. Komarov, *President of the Academy* ; O. J. Schmidt, *Vice-President* ; I. A. Chudakov, *Vice-President*.

Members : A Bach, A. Bogomolets, N. Boordenko, A. Fersman, A. Froomkin, A. Joffe, P. Kapitza, D. Prianeshnikov, A. Speransky, P. Stepanov, L. Shtern, I. Tarle, V. Vernadsky, I. Vinogradov.

CONCLUSION

SIR RICHARD GREGORY, BT., F.R.S.

THE enthusiasm with which this meeting of the Division for Social and International Relations of Science was received from the outset not only shows great public interest, but also represents wide and encouraging general support for whatever scientific men may have to say. Arising out of this Conference there will, I hope, be committees appointed to take up some of the main points which have been brought forward, and to prepare considered statements upon them. That would be a more useful result of this Conference than resolutions from the Conference itself that this, that, or the other science is neglected in this, that or the other departments. What has inspired and stimulated me is the welcome given to this Conference from the outset not only by men of science themselves of high authority, but by citizens representing the many nationalities now in London who welcomed such a conference in the international spirit. This Conference was not called to justify British science or to show that science as such was a great force. It was called in order that we might consider some of these post-war problems as problems for all people. Among the subjects to be referred to the Committee of the Division for Social and International Relations of Science is one put to me to-day, namely, that the British Association should ensure the most immediate utilisation of science in the conduct of the war. That is a present war problem. What can be done usefully by this Division in that way will be done. Having attended every one of these sessions, representing an assembly of thoughtful citizens of our community, I can assure you that we will do what we can to implement some of the main points which have been brought forward during those sessions.

I should like to say how very highly we appreciate the kindness of the Managers of this Institution in letting us assemble here for these three days, including a Sunday. There is no more appropriate place in the world at which such a meeting could be held, since it was founded by an American, Count Rumford, who combined all the qualities that we want now to be joined together in our efforts for the welfare of the whole world—the qualities of soldier, administrator, man of science and social reformer. To-day we need to combine all these in framing a policy for a new world order.

I have finally to present a Declaration of Scientific Principles, which has been called a Charter of Science. The origin of this was a suggestion that came to the British Association that we should help to make a statement of the scientific principles of democracy. For the British Association to do that without a good deal of consideration would be inappropriate. But we may very properly make a contribution by stating what are the democratic principles of science; because science is a true and great democracy, in which there are no social, racial or geographical divisions, where merit is determined only by contributions to knowledge. So it seemed better to frame a general statement of our principles of science, a statement to which any man of free mind, who has the spirit of science within him, should be able to subscribe, whatever his nationality. If he cannot subscribe to it, he is not what we should call a free man of science. This statement was drafted by a committee of the Division and has been approved by the Council of the British Association. I will therefore read it as it stands rather than make a statement upon it. It is deliberately drawn in terms of generalities, to represent not a creed, but the principles by which progressive knowledge has been obtained and used by the human race in service to high ideals.

DECLARATION OF SCIENTIFIC PRINCIPLES

Intellectual freedom is an essential condition of progressive human development. Throughout the ages, individual scientific workers have been forced to fight and to suffer in order that life and intellect may be preserved from the effects of unreasoning prejudice, stagnation and repression. To-day they feel compelled to proclaim their special responsibility in the struggle against any subjection which would lead to the betrayal of intellectual liberty.

The war now devastating our world involves an age-old conflict of ideas. Liberal minds of the last generation were convinced that the battle for independence of thought and free expression of opinion was finally won; yet once again this conviction is being violently assailed. The fight to maintain it must perforce be resumed, for the danger of losing the heritage of freedom seems graver than ever before.

During the past third of a century, changes in the conditions of life have come about, more profound than any in human history. Distance has been virtually abolished; cognisance of events has become simultaneous throughout the world; all men have become neighbours. Fresh discoveries open up

undreamed-of potentialities for good or for evil, but their proper use demands correspondingly high ethical standards.

While only a century ago the village was an almost self-sufficing unit, to-day the world is our unit. To such a disturbing change of outlook and obligations we are not yet attuned, and we must readjust our ways of living, for only by the fullest and freest adaptation of ideas to new conditions can this readjustment be achieved. Intense mental effort and clear vision are now needed.

In the past, freedom for the written and spoken word was desirable; to-day, complete freedom of thought and interchange of knowledge and opinion are supreme necessities. Full freedom of expression is the very essence of science as well as democracy: where thought is enslaved science, like democracy, withers and decays. Men of science must, therefore, declare clearly and emphatically the principles which underlie their beliefs and guide their conduct.

Accordingly the principles of the Fellowship of Science are here affirmed, and it is maintained that any policy or power which deprives men or nations of their free practice convicts them as agents of an iniquity against the human race.

1. *Liberty to learn, opportunity to teach and power to understand are necessary for the extension of knowledge, and we, as men of science, maintain that they cannot be sacrificed without degradation to human life.*

2. *Communities depend for their existence, their survival and advancement, on knowledge of themselves and of the properties of things in the world around them.*

3. *All nations and all classes of society have contributed to the knowledge and utilisation of natural resources, and to the understanding of the influence they exercise on human development.*

4. *The service of science requires independence combined with co-operation, and its structure is influenced by the progressive needs of humanity.*

5. *Men of science are among the trustees of each generation's inheritance of natural knowledge. They are bound, therefore, to foster and increase that heritage by faithful guardianship and service to high ideals.*

6. *All groups of scientific workers are united in the fellowship of the Commonwealth of Science, which has the world for its province and the discovery of truth as its highest aim.*

7. *The pursuit of scientific inquiry demands complete intellectual freedom and unrestricted international exchange of knowledge; and it can flourish only through the unfettered development of civilised life.*

REPORT OF THE COUNCIL TO THE GENERAL COMMITTEE FOR THE YEAR 1940–41

Obituary.

The Council have to deplore the loss by death of the following office-bearers and supporters :—

Prof. F. Aveling
Rt. Hon. Lord Cadman, G.C.M.G., F.R.S.
Mr. C. W. Duckworth
Sir Arthur Evans, F.R.S.
Prof. A. G. Green, F.R.S.
Prof. B. P. Haigh
Sir A. W. Hill, F.R.S.
Dr. H. S. Hele-Shaw, F.R.S.
Dr. G. W. C. Kaye, F.R.S.
Mr. C. H. Merz
Dr. Otto Petterssen
Prof. J. C. Philip, F.R.S.
Mr. Hugh Richardson
Sir Albert Seward, F.R.S.
Dr. C. Shearer, F.R.S.
Rt. Hon. Lord Stamp, G.C.B., G.B.E.
Prof. Vito Volterra
Prof. Miles Walker, F.R.S.
Sir Arnold Wilson, K.C.I.E., C.S.I., C.M.G., D.S.O.

The Association was represented at memorial services for the three ex-Presidents of the Association named above—at that for Sir Arthur Evans by Prof. Sir Edward Poulton, F.R.S., and Prof. J. L. Myres, F.B.A.; at that for Sir Albert Seward by Prof. F. T. Brooks, F.R.S., and Prof. Allan Ferguson; and at that for Lord Stamp by Sir Richard Gregory, Bt., F.R.S., Prof. Allan Ferguson, and Dr. O. J. R. Howarth. The following resolution was sent to the relatives of Lord Stamp, who, it will be remembered, lost his life through enemy action, together with Lady Stamp and one of their sons :—

The President and General Officers, on behalf of the Council of the British Association, offer their deepest sympathy to members of the family of Lord and Lady Stamp on their most grievous bereavement. The President and General Officers gratefully recall Lord Stamp's wise guidance of the finances of the Association during his term of office as General Treasurer, and the inspiration of his address to the Association as its President will not soon be forgotten. Lord Stamp's wide interests and high ideals have left their impress on our national life at many points. Science owes much to him for its advancement, and all who shared with him that one among his many labours for the common good will profoundly deplore his loss.

Professor Philip was an ordinary member of the Council at the time of his death.

Division for the Social and International Relations of Science.

At a meeting of the Divisional Committee, held on July 17, 1941, it was ordered that a message be forwarded to the U.S.S.R. Academy of Sciences in the following terms :—

The Divisional Committee for the Social and International Relations of Science, being a constituent committee of the British Association for the Advancement of Science, offers greetings to the U.S.S.R. Academy of

Sciences, rejoices that the services of science in both countries are now being utilised to compass the defeat of the common enemy, and expresses the fervent hope that British and Russian science may in the near future be united in application to the establishment of a new and happier ordering of the affairs of mankind.

The following reply was received :—

The Academy of Sciences of the U.S.S.R. sends warmest greetings to the Committee for Social and International Relations of the British Association for the Advancement of Science. With the help of scientists of both our countries the united peoples of Great Britain and the Soviet Union will triumph in the war for the liberation of humanity from fascist tyranny.

(*Signed*) OTTO SCHMIDT, *Vice-President, Academy of Sciences of the U.S.S.R.*

Conference on Science and World Order.—During the past year the activities of the Association, save for certain routine business, had continued almost wholly in suspense until at the meeting of the Divisional Committee referred to above it was resolved to set on foot arrangements for a Conference of the Division, to deal with various topics under the general title of Science and World Order. This Conference took place at the Royal Institution, Albemarle Street, London (by kind permission of the Managers of the Institution), on Friday, Saturday, and Sunday, September 26, 27, 28, 1941. Its proceedings have been or will be fully reported elsewhere, so that it is necessary to state here only that its appeal and the public interest taken in it far exceeded the expectations of the Committee, and the Council feel that the decision to hold the Conference was very fully justified. The Association has gained many new points of contact with public bodies and with individuals interested in its objects, and many lines of fresh activity for the executive, the Division, and the Council are being followed up.

Declaration of Scientific Principles.

At the Conference mentioned above, the President, Sir Richard Gregory, Bt., F.R.S., announced a Declaration of Scientific Principles which had been drafted by a sub-committee of the Division, and adopted by the Council. It will be published among the transactions. The decision to draft such a Declaration followed upon a suggestion made originally to the American Association for the Advancement of Science by one of its members, that a Charter of Democracy on scientific lines should be prepared by the two Associations jointly. This suggestion has not since been given effect by the American Association, and such a charter was felt to be beyond the scope of the British Association ; but the American Association has been kept fully informed of the action taken in connection with our own Declaration.

General Officers and Council.

The General Officers are nominated by the Council for reappointment :—

General Treasurer, Prof. P. G. H. Boswell, F.R.S.
General Secretaries, Prof. F. T. Brooks, F.R.S., Prof. Allan Ferguson.

Council.—It is recommended that advantage be again taken of the Lord President's licence, quoted in last year's Report of the Council, to modify in certain particulars action prescribed by the Statutes, and that no change be made in the personnel of the Council. (For names, see p. 2.)

Finance.

The President and the General Treasurer, on behalf of the Council, have gratefully acknowledged a gift of $539, being a balance in the hands of the Philadelphia Committee for the meeting of the American Association for the Advancement of Science held in that city in December, 1940, and voted to the funds of the British Association by that Committee. It is felt that this money might be most appropriately used as a contribution to the expenses of the Conference on Science and World Order, and this is recommended accordingly.

The General Treasurer's Account [1] for the financial year ending March 31, 1941, has been audited, and is presented to the General Committee. Grants have been made to research committees (and in one instance to an individual) in accordance with the schedule appended to the Account.

Grants to Research Committees, 1941–42.

The following grants applied for by the Committees named for the ensuing year have been approved by the General Treasurer on behalf of the General Committee or the Council.

Committee.	*Grant.* £	*Fund charged.*
Seismological Investigations	100	Caird Fund
Mathematical Tables :	25	Mathematical Tables Fund
Printing of Airy Integral Tables . . .	110	Caird Fund
Printing of Legendre Functions . . .	80	Caird Fund
Plymouth Marine Laboratory	50	Grants Equalisation Fund
Zoological Record . .	50	Grants Equalisation Fund
Insular faunas . . .	10	Grants Equalisation Fund
Bird Behaviour . .	40	Caird Fund
Freshwater Biological Station, Windermere . .	75	Grants Equalisation Fund
National collection of type cultures of algae and protozoa . . .	25	Grants Equalisation Fund
Kent's Cavern . . .	5	Hobson Fund

Down House.

There is nothing to add to the report made by the Down House Committee last year, as conditions at the house are unchanged. The financial statement for the year is included as usual in the General Treasurer's Account.

The precipitation for the year 1940 read from the standard rain gauge was 32·72 in., compared with 39·36 in. in 1939, and 25·93 in. in 1938.

[1] The Account is circulated separately to members of the General Committee, and may be obtained by others on application to the Secretary.

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